REPAIR AND OVERHAUL

ENGINE CYLINDERS
WITH SEPARATE STEEL HEAD

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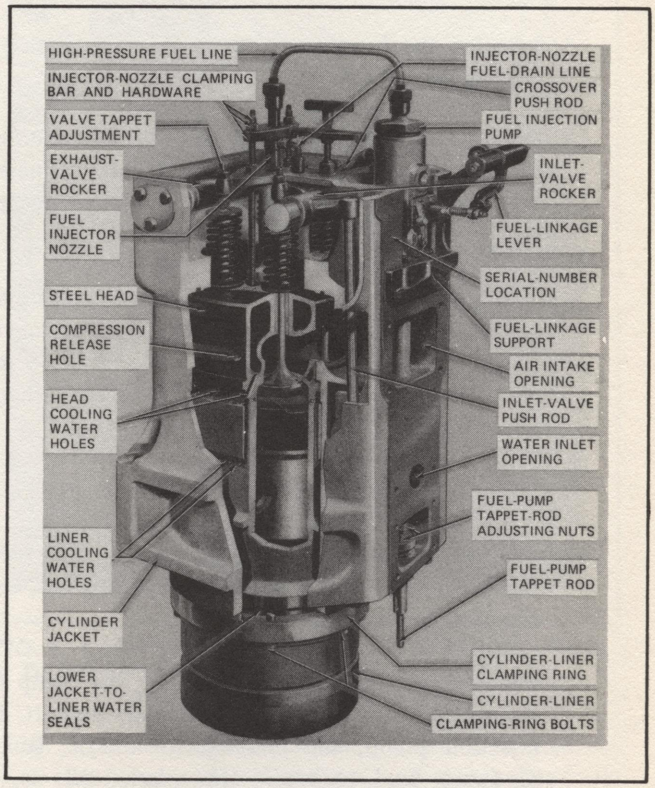
HIGH-PRESSURE FUEL LINE
INJECTOR-NOZZLE CLAMPING BAR AND HARDWARE
VALVE TAPPET ADJUSTMENT
EXHAUST-VALVE ROCKER
FUEL INJECTOR NOZZLE
STEEL HEAD
COMPRESSION RELEASE HOLE
HEAD COOLING WATER HOLES
LINER COOLING WATER HOLES
CYLINDER JACKET
LOWER JACKET-TO-LINER WATER SEALS
INJECTOR-NOZZLE FUEL-DRAIN LINE
CROSSOVER PUSH ROD
FUEL INJECTION PUMP
INLET-VALVE ROCKER
FUEL-LINKAGE LEVER
SERIAL-NUMBER LOCATION
FUEL-LINKAGE SUPPORT
AIR INTAKE OPENING
INLET-VALVE PUSH ROD
WATER INLET OPENING
FUEL-PUMP TAPPET-ROD ADJUSTING NUTS
FUEL-PUMP TAPPET ROD
CYLINDER-LINER CLAMPING RING
CYLINDER-LINER
CLAMPING-RING BOLTS

FIG. 1. CYLINDER ASSEMBLY, CUTAWAY VIEW.

FIG. 1, E-14984A

SCOPE

This instruction covers "back-shop" operations for engine cylinders and is presented on the assumption that the complete assembly is to be processed. When processing "short assemblies", it will be necessary to extract the portions of this instruction that are applicable. For a complete description of the various types of engine cylinders (with separate steel head) together with the "running-repair" operations associated with these cylinders, refer to publication GEK-61272.

INSPECTION — CYLINDER ASSEMBLY

Prior to any disassembly, place the cylinder assembly in a servicing fixture and make a preliminary inspection. Make a record of the conditions found, as they may affect the extent and nature of the rework required. A thorough

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the General Electric Company.

Verify numbers for parts, tools, or material by using the Renewal Parts or Tool Catalogs, or contact your General Electric representative for assistance. Do not order from this publication.

GENERAL ELECTRIC

inspection will often show conditions that existed on the engine from which the cylinder was removed and which should be reported and corrected.

1. Record the serial number of the cylinder assembly, found on the top, left, front face of the jacket. See Fig. 1 for location.

2. Examine the cylinder assembly for missing or broken components.

3. Examine the head area for signs of overheating or mechanical damage.

4. Examine the exterior, particularly at the holddown lugs, for signs of damage due to improper tightness of holddown bolts, and the area adjacent to the exhaust port for signs of overheating.

5. Examine intake port area. If carbon has built up to a depth in excess of 1/8 in., other cylinders on the engine from which this cylinder was removed may need port cleaning to avoid a potential turbocharger failure.

CYLINDER DISASSEMBLY

1. Remove cylinder cover and all hardware used to secure the cover; that is, clamp knob, clamping bar, stud, stop nut, and seal washer.

2. Remove the high-pressure fuel line, the pump fuel linkage, fuel-linkage lever, fuel-linkage support, fuel injection pump, the fuel injector nozzle, and all hardware used to secure the nozzle; that is, the clamping bar, nuts, stop nuts, studs, seal washers and lockwashers (securing bottom end of studs to cylinder jacket).

CAUTION: *Apply protective covers and plugs to fuel-injection pump and nozzle to prevent entrance of dirt. Remove and discard the copper gasket from the lower end of the nozzle.*

3. Remove cover which protects the fuel pump tappet rod adjustment. Remove push rod thru top of cylinder jacket. Using two wrenches, loosen umbrella locking nut, then disassemble and remove the adjustable fuel-pump tappet rod. Refer to Fig. 1 and 2.

4. Remove the four rocker-shaft end plates. Then remove the rocker shafts, rockers, spacers and thrust washer (if used). Refer to Fig. 1 and 3.

5. Remove the compression-release plug, adapter and associated hardware.

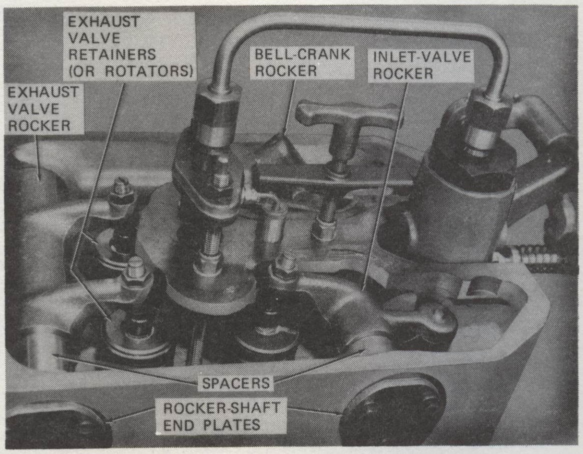
EXHAUST VALVE RETAINERS (OR ROTATORS)
BELL-CRANK ROCKER
INLET-VALVE ROCKER
EXHAUST VALVE ROCKER
SPACERS
ROCKER-SHAFT END PLATES

FIG. 3. UPPER CYLINDER COMPONENTS.

FIG. 3, E-22728

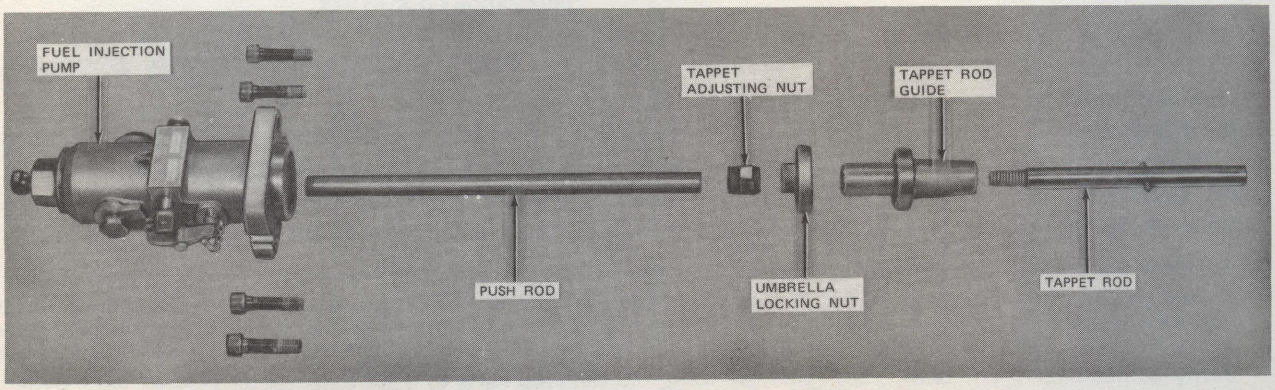
FUEL INJECTION PUMP
TAPPET ADJUSTING NUT
TAPPET ROD GUIDE
PUSH ROD
UMBRELLA LOCKING NUT
TAPPET ROD

FIG. 2. FUEL-INJECTION PUMP PUSH-ROD ARRANGEMENT.

FIG. 2, E-9996A

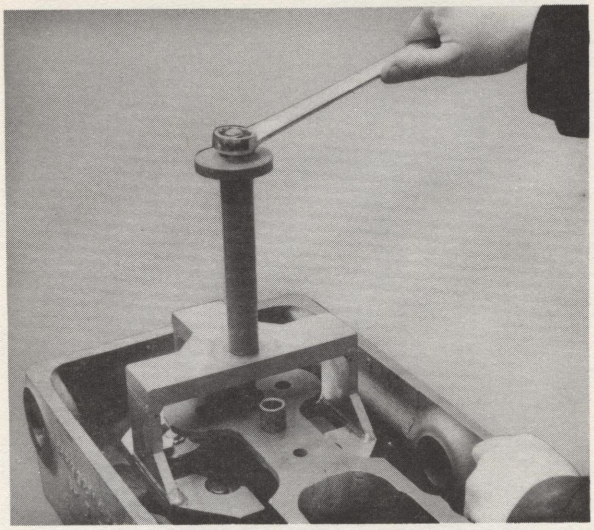

FIG. 4. COMPRESSING ALL VALVE SPRINGS MANUALLY, USING DEPRESSOR, PART 147X1945.

FIG. 4, E-21506

6. Remove the four valves and associated hardware. Use the quadruple valve spring depressor, Part 147X1945, either manually or hydraulic-powered by ram and pump set, Part 147X1959. Valve springs can also be depressed individually using the single valve spring depressor, Part 147X1886. Refer to Fig. 4, 5 and 6.

7. Remove the clamping-ring bolts and the cylinder-liner clamping ring.

NOTE: *Early-production cylinders (1964-1966) with belly-band type liners had two dowels which secured and aligned the clamping ring and liner. This arrangement assured proper alignment of the cooling water passages between the jacket and liner. To disengage the liner and clamping ring, it is necessary to shear these two dowels.*

To shear the dowels, secure the cylinder assembly to prevent rotation, position the cylinder-liner clamping ring remover, Part 147X1456, so the dowels in the tool register in the clamping-ring bolt holes (Fig. 7), and strike the outer end of the bar to cause the clamping ring to rotate and shear the locating dowels (roll pins). Remove the clamping ring and dig out the sheared pieces of the roll pins. Smooth off any upsets caused by the shearing operation.

8. Position the cylinder in the press, and install the four valve-guide protectors over the valve guides. Use the cushioned post to protect the head and liner when they fall free from the jacket. See Fig. 8.

9. Press the head and liner from the cylinder jacket.

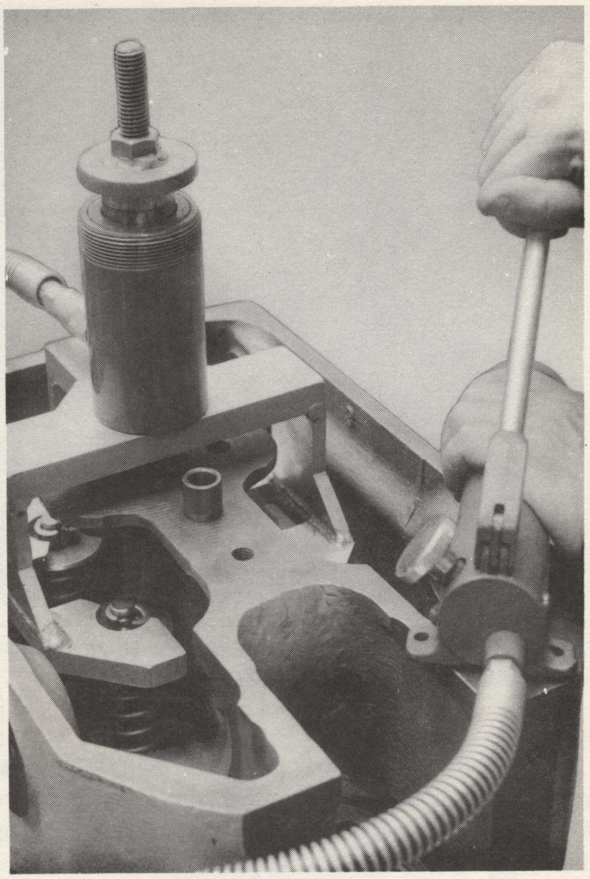

FIG. 5. COMPRESSING ALL VALVE SPRINGS, USING DEPRESSOR, PART 147X1945, AND RAM AND PUMP SET, PART 147X1959.

FIG. 5, E-21507

10. Separate the head and liner. Examine the head-to-liner seal and seal surfaces, and the cooling-water contact surfaces. If parts have excessive corrosion, erosion, sludge or scale, take action to correct the condition on the engine (and the locomotive cooling-water system) from which the cylinder was removed.

CLEANING

Thoroughly clean all component parts to facilitate inspection and repair, if required. Special attention should be given to gasket seating surfaces and any surface requiring inspection for cracks. *

INSPECTION AND REWORK

CYLINDER JACKET

Visually check for indication of cracks, especially in the areas surrounding holes. Magnetic particle check for cracks in the areas surrounding the cylinder holddown bolt holes.

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*Revisions are indicated by marginal bars.

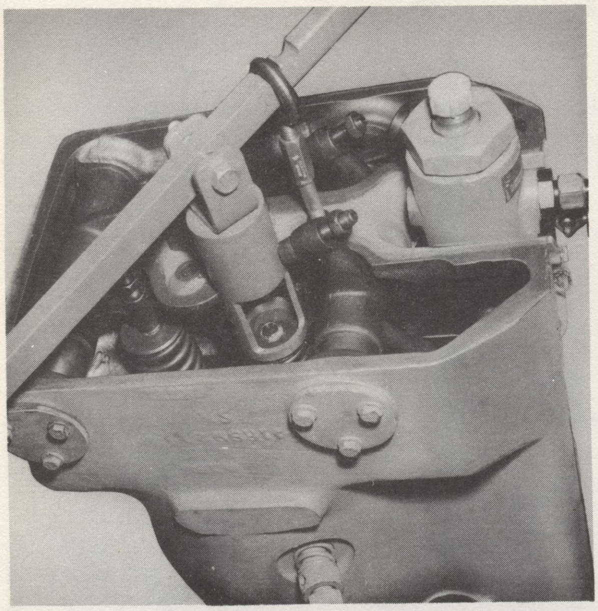


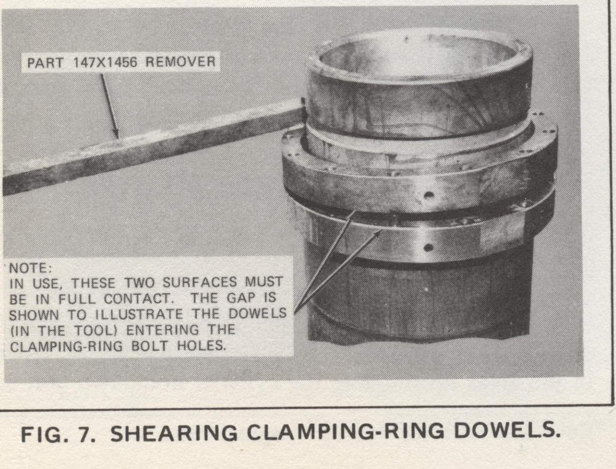
FIG. 6. COMPRESSING INDIVIDUAL VALVE SPRING, USING DEPRESSOR, PART 147X1886.

Remove all accumulations of carbon from the air intake opening. Clean all threaded holes, using a tap if required. This is especially necessary for the eight clamping-ring bolt holes.

Make certain all gasket grooves are clean and free of old gasket material.

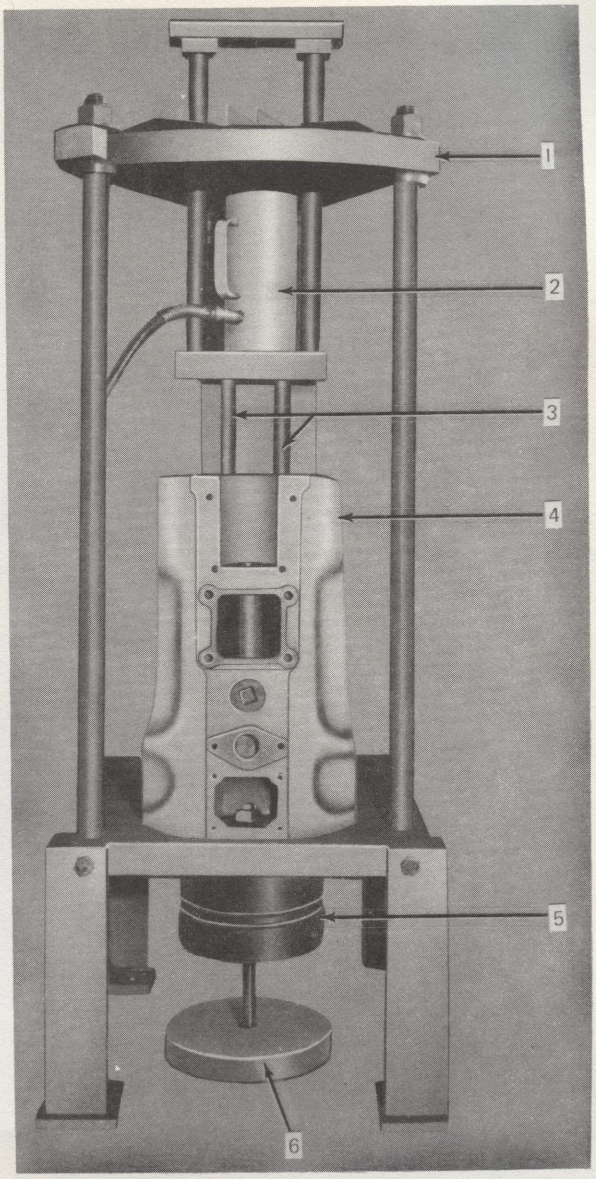
Check O-ring fits for the fuel-injector nozzle and the lower liner seal. Polish corroded surfaces, and achieve the finishes specified in the detailed views in Fig. 9.

Measure and record significant bore diameters given in Fig. 9. This data will be used at reassembly of the cylinder.



NOTE:
IN USE, THESE TWO SURFACES MUST BE IN FULL CONTACT. THE GAP IS SHOWN TO ILLUSTRATE THE DOWELS (IN THE TOOL) ENTERING THE CLAMPING-RING BOLT HOLES.

FIG. 7. SHEARING CLAMPING-RING DOWELS.



REF.	DESCRIPTION
1	STAND
2	HYDRAULIC PRESS
3	VALVE-GUIDE PROTECTORS
4	CYLINDER JACKET
5	CYLINDER LINER
6	CUSHIONED POST

FIG. 8. VIEW OF CYLINDER INSTALLED IN STAND WITH HYDRAULIC PRESS TO REMOVE HEAD AND LINER.

CYLINDER HEAD

Thoroughly clean the head, including the removal of all carbon deposits in the air-intake and exhaust-outlet ports.

FIG. 8, E-13555A

FIG. 7, E-16543A

FIG. 6, E-21509

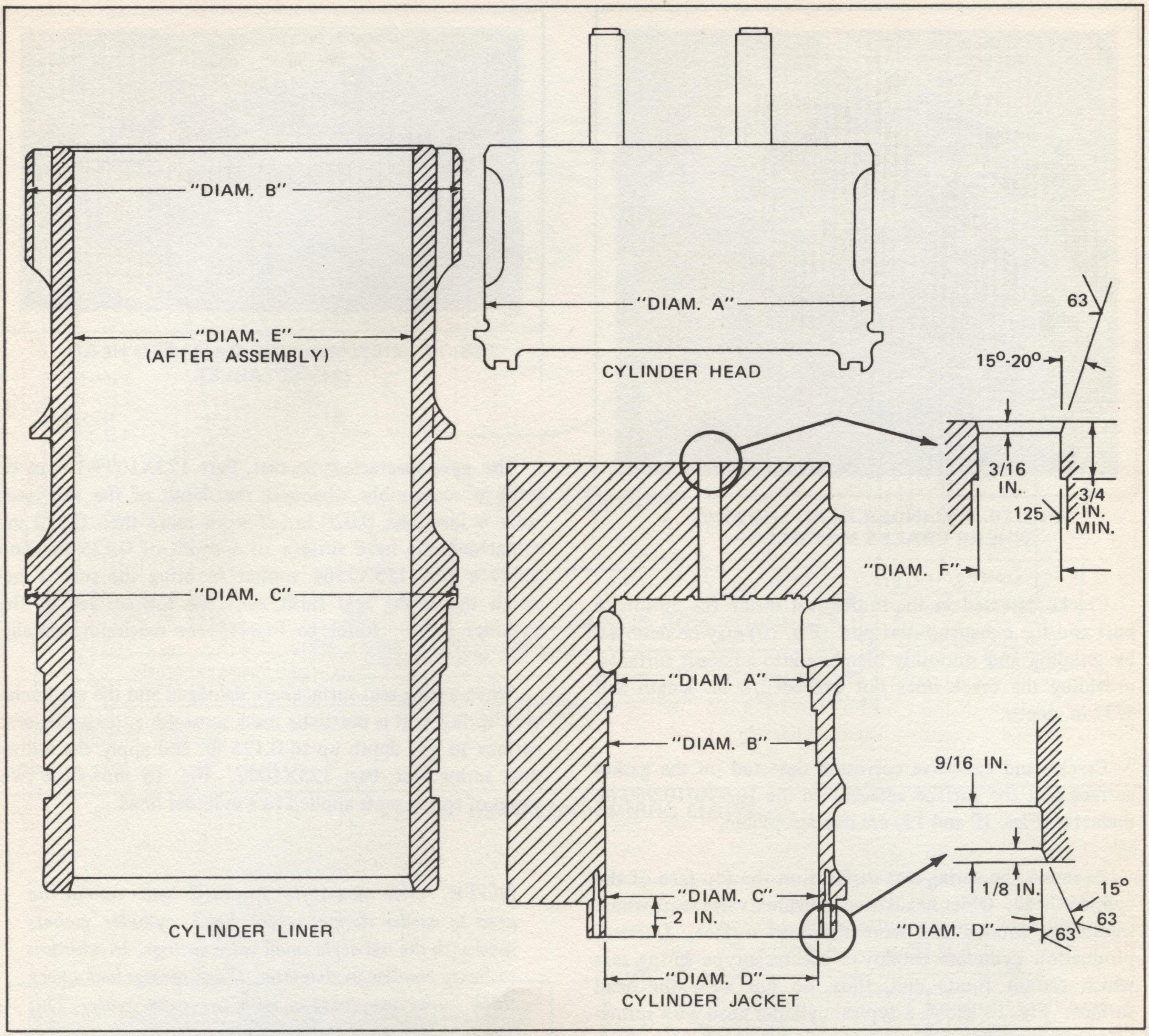

"DIAM. B"
"DIAM. E"
(AFTER ASSEMBLY)
"DIAM. C"
CYLINDER LINER
"DIAM. A"
CYLINDER HEAD
63
15°-20°
3/16 IN.
125
3/4 IN. MIN.
"DIAM. F"
"DIAM. A"
"DIAM. B"
"DIAM. C"
2 IN.
"DIAM. D"
CYLINDER JACKET
9/16 IN.
1/8 IN.
15°
63
"DIAM. D"
63

FIG. 9, E-14995B

FIG. 9. SIGNIFICANT CYLINDER DIMENSIONS.

Inspect the gasket groove in the head for damage (wear, corrosion, cracks). Detect the presence of cracks and the extent of cracks using Magnaflux* test equipment. Refer to Fig. 10, 11, 12 and 13. Be especially critical of:

1. The bottom surface of the gasket groove, which must be a 125C** microinch finish, and
2. Cracks at the inside corner of the gasket groove (Fig. 10). If no cracks are present but the bottom of the gasket groove is damaged, correct by remachining the groove and adjacent surfaces. The remachined head must meet all dimensions on Fig. 13.

If cracks are found around the inside corner of the gasket groove, they too may be corrected by remachining the gasket groove and adjacent surfaces, as outlined above, providing:

1. Cracks are not more than 120 degrees in length, and
2. Cracks will not accept a 0.0025 in. (0,0635 mm) thickness gage.

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*Product of Magnaflux Corp.

**This is a finish produced in a rotating-type machine, such as a lathe, with the finish grooves all concentric with the center of the work piece.

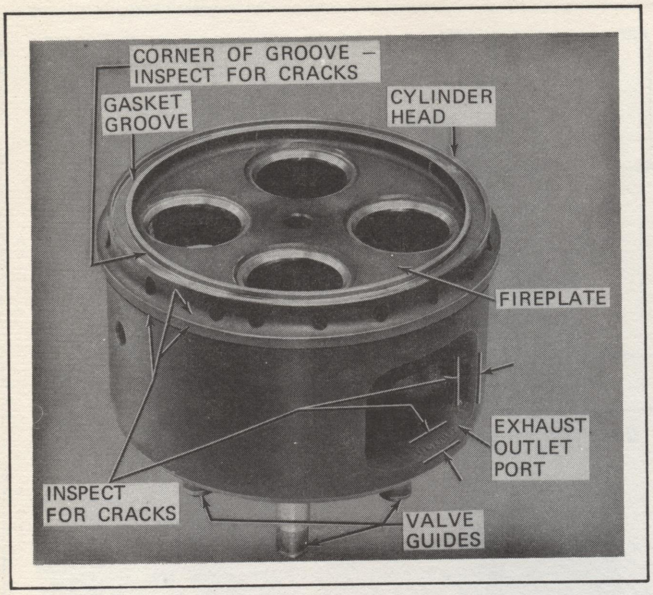


FIG. 10. CYLINDER HEAD SHOWING WHERE CRACKS MAY OCCUR.

Cracks detected in the radius just inside the air-intake port and the exhaust-outlet port (Fig. 10) may be removed by grinding and smoothly blending into adjacent surfaces, providing the crack does not exceed 3/8 in. length and 1/32 in. depth.

Cracks and excessive corrosion detected on the gasket surface and the surface adjacent to the 10.990/10.960-in. diameter (Figs. 10 and 13) are not acceptable.

Examine the spring-seat surfaces on the top face of the cylinder head. Older heads used individual valve seats which sometimes rotated and wore the head surface. Current-production cylinders employ a spectacle-type spring seat which cannot rotate and, thus, do not wear the head surface. Fig. 14 shows a typical cylinder head with spring-seat wear patterns.

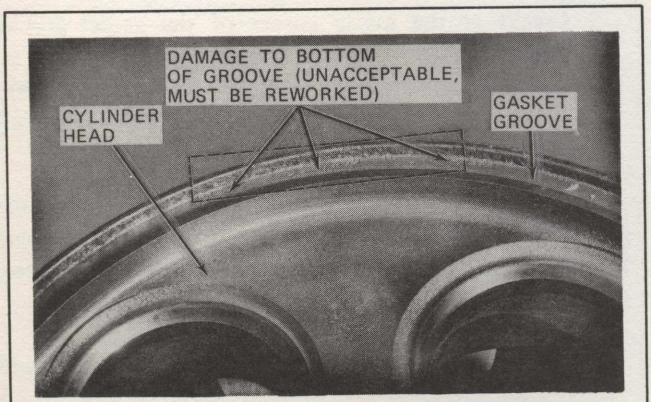


FIG. 11. VIEW SHOWING DAMAGED HEAD (UNACCEPTABLE).

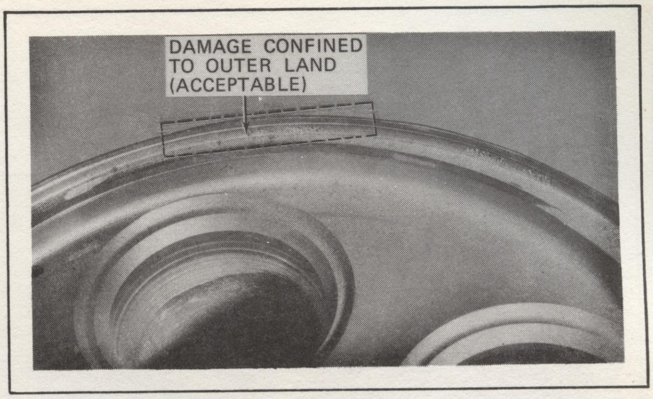


FIG. 12. VIEW SHOWING DAMAGED HEAD (ACCEPTABLE).

The new spectacle-type seat, Part 123X1079-1, can be used at reassembly whenever the depth of the valve-seat wear is less than 0.020 in.; if worn more than 0.020 in., remachine the head surface to a depth of 0.125 in., and apply a Part 115X2364 washer to bring the surface beneath the spring seat flush with the top surface of the cylinder head. Refer to Fig. 15 for machining details.

When spring-seat surfaces are damaged and the spectacle-type spring seat is not to be used, remachine the spring-seat surface to any depth up to 0.125 in. and apply the individual spring seat, Part 123X1042. Fig. 16 shows the two types of spring seats applied to a cylinder head.

NOTE: *The new-style spectacle seat cannot be used in earlier design, steel head cylinder jackets used with the old-style small valve springs. In addition to being smaller in diameter, these springs had a very thick lower seat integral with the valve guide. This raised the lower end of the spring approximately one in. above the head.*

Inspect the compression release hole, and make certain it is free of carbon for its full 2-1/4-in. depth. Check the diameter of the hole. By present standards, it should be 3/16 in.; if not, redrill to this diameter.

Inspect the Lubrite coating on the head. If it is corroded, the head must be cleaned and re-Lubrited. See the instructions on Coating Liners, Heads and Pistons. Patches bare of coating and not corroded may be touched up with molybdemum disulphide or a suitable equivalent.

Inspect the valve seats. Refer to VALVE SEATS, Seat Surface section.

FIG. 12, E-16134A

FIG. 11, E-16133

FIG. 10, E-21260A

FIG. 15, E-22721

FIG. 14, E-21367

FIG. 13, E-16135C

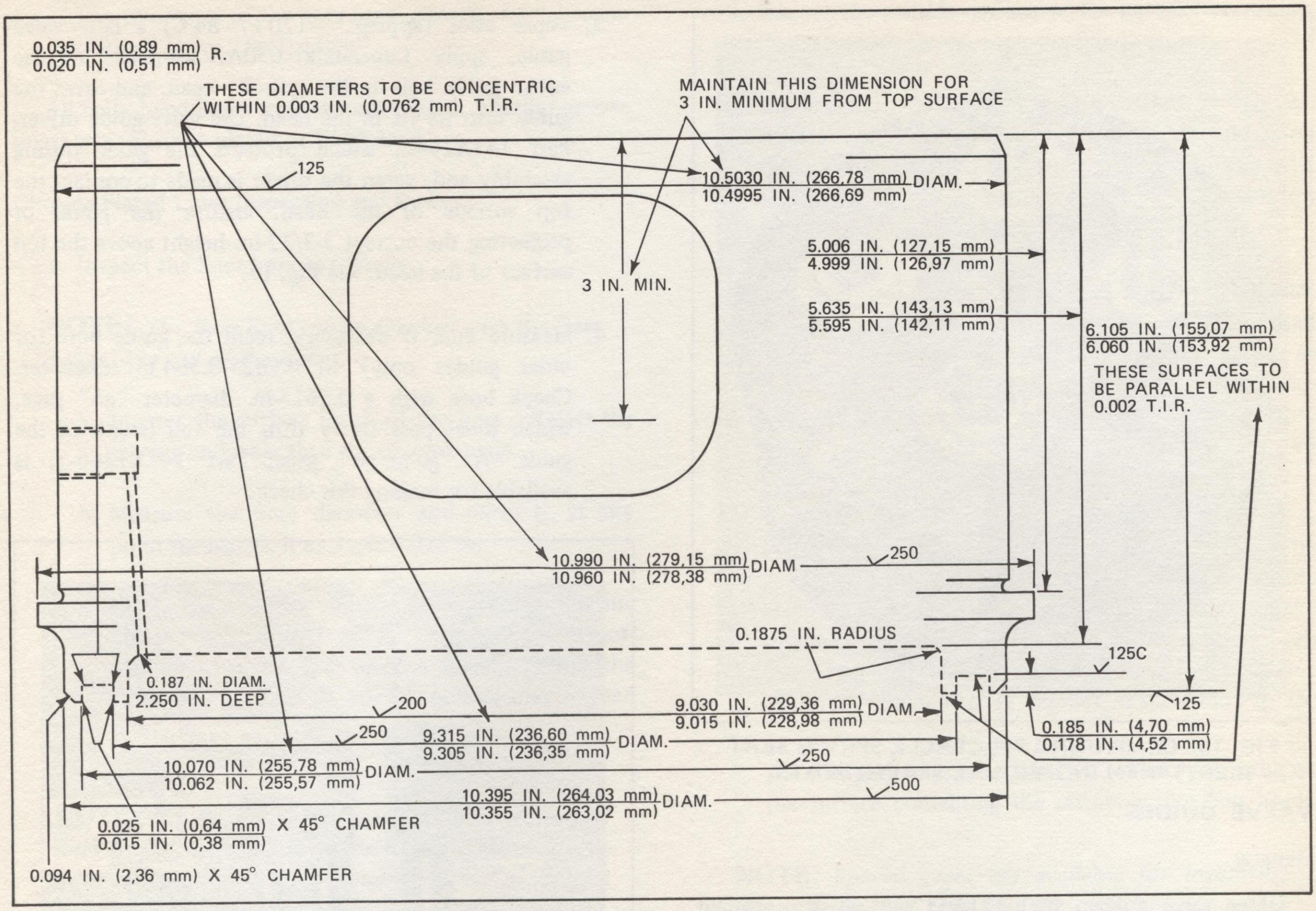

0.035 IN. (0,89 mm) / 0.020 IN. (0,51 mm) R.
THESE DIAMETERS TO BE CONCENTRIC WITHIN 0.003 IN. (0,0762 mm) T.I.R.
MAINTAIN THIS DIMENSION FOR 3 IN. MINIMUM FROM TOP SURFACE
125
10.5030 IN. (266,78 mm) / 10.4995 IN. (266,69 mm) DIAM.
5.006 IN. (127,15 mm) / 4.999 IN. (126,97 mm)
3 IN. MIN.
5.635 IN. (143,13 mm) / 5.595 IN. (142,11 mm)
6.105 IN. (155,07 mm) / 6.060 IN. (153,92 mm)
THESE SURFACES TO BE PARALLEL WITHIN 0.002 T.I.R.
10.990 IN. (279,15 mm) / 10.960 IN. (278,38 mm) DIAM
250
0.1875 IN. RADIUS
125C
0.187 IN. DIAM. / 2.250 IN. DEEP
200
9.030 IN. (229,36 mm) / 9.015 IN. (228,98 mm) DIAM.
125
0.185 IN. (4,70 mm) / 0.178 IN. (4,52 mm)
250
9.315 IN. (236,60 mm) / 9.305 IN. (236,35 mm) DIAM.
10.070 IN. (255,78 mm) / 10.062 IN. (255,57 mm) DIAM.
250
10.395 IN. (264,03 mm) / 10.355 IN. (263,02 mm) DIAM.
500
0.025 IN. (0,64 mm) / 0.015 IN. (0,38 mm) X 45° CHAMFER
0.094 IN. (2,36 mm) X 45° CHAMFER

FIG. 13. HEAD CONDEMNING LIMITS.

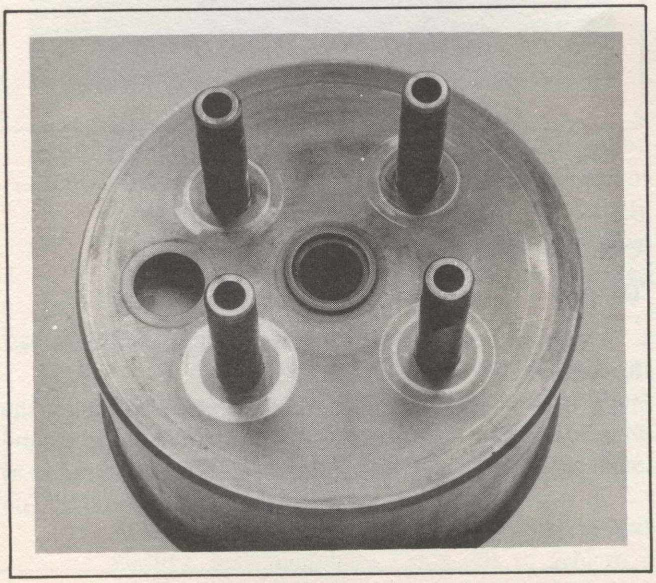


FIG. 14. DAMAGED SPRING-SEAT SURFACES.

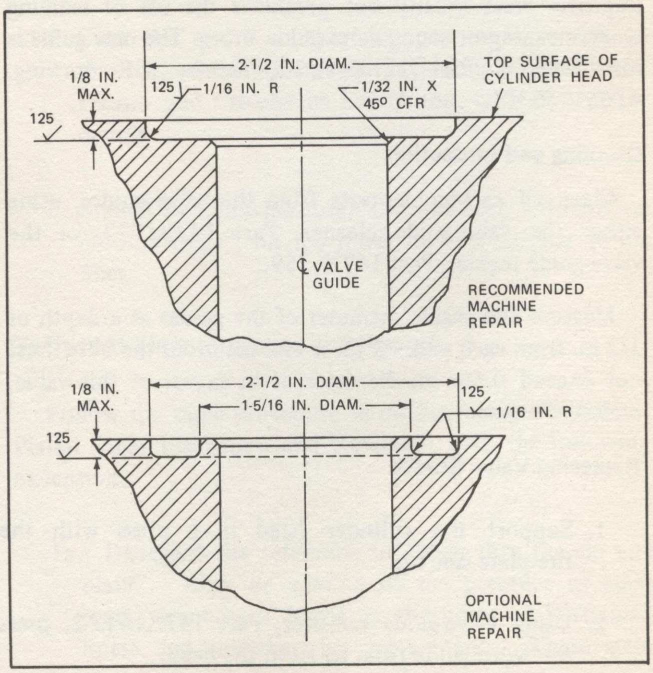

2-1/2 IN. DIAM.
TOP SURFACE OF CYLINDER HEAD
1/8 IN. MAX.
125
1/16 IN. R
1/32 IN. X 45° CFR
125
℄ VALVE GUIDE
RECOMMENDED MACHINE REPAIR
2-1/2 IN. DIAM.
1/8 IN. MAX.
1-5/16 IN. DIAM.
125
1/16 IN. R
125
OPTIONAL MACHINE REPAIR

FIG. 15. REWORK DIMENSIONS FOR DAMAGED SPRING-SEAT SURFACES.

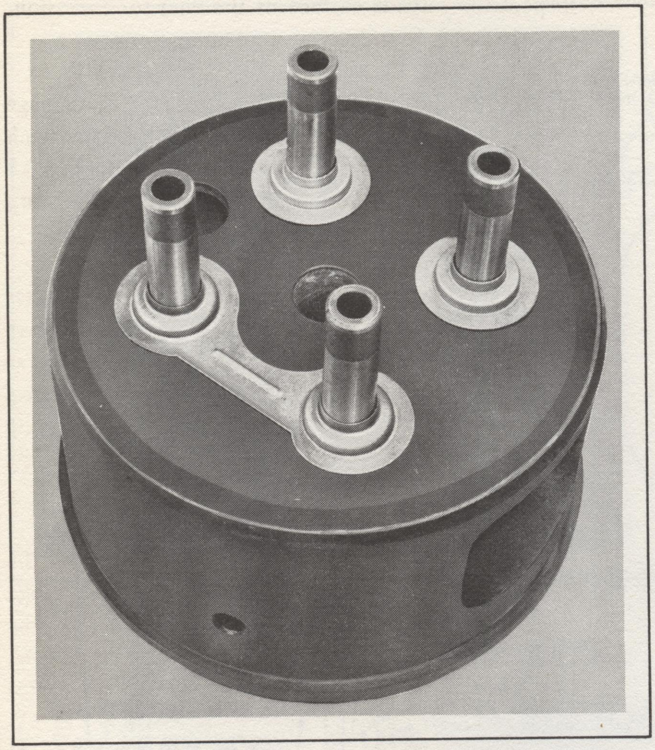


FIG. 16. COMPARING SPECTACLE SPRING SEAT (LEFT) WITH INDIVIDUAL SPRING SEATS.

FIG. 16, E-21368A

VALVE GUIDES

General

Older valve guides, Part 121X1126-1, were machined from special-quality cast iron. Since early 1977 this same guide has been given a Tufftrided△ surface treatment which improves wear quality but precludes the use of reaming when cleaning or sizing valve-guide bores. The new guide is identified as Part 121X1126-2, or by GE drawing, 41B514563P1.

Cleaning and Inspection

Clean all carbon deposits from the valve guides, using either the valve-guide cleaner, Part 147X1072, or the valve-guide reamer, Part 147X1359.

Measure the inside diameter of the guides at a depth of 1/2 in. from each end. At these two locations the bore must not exceed 0.566 in. diameter; if in excess of this value, replace the guide.

Replacing Valve Guides

1. Support the cylinder head in a press with the fire-plate side up.
2. Using valve-guide remover, Part 147X1045-2, press the worn guide from its fit in the head.
3. Super cool (approx. −120 F/−84 C) a new valve guide, apply Lubriplate† 630AA lubricant to the entire guide hole in the cylinder head, and drive the guide into its fit in the head. Use valve-guide driver, Part 147X1442, which protects the guide during assembly and, when the driver is made to contact the top surface of the head, assures the guide of projecting the correct 3-3/32-in. height above the top surface of the head. See Fig. 17.
4. Measure and, if necessary, ream the guide bore (of older guides only) to 0.5625-0.564 in. diameter. Check bore with a 0.5615-in. diameter "go" gage, which must pass freely thru the full length of the guide. A "go-no go" gage, Part 147X1366-1, is available for making this check.

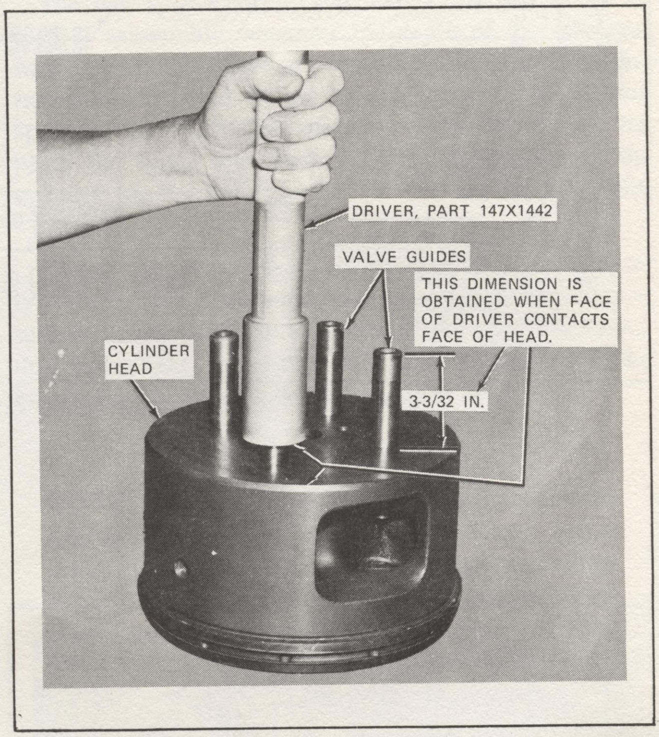

DRIVER, PART 147X1442
VALVE GUIDES
THIS DIMENSION IS OBTAINED WHEN FACE OF DRIVER CONTACTS FACE OF HEAD.
CYLINDER HEAD
3-3/32 IN.

FIG. 17. VALVE-GUIDE DRIVER, PART 147X1442, PROTECTS AND CORRECTLY POSITIONS GUIDE DURING INSTALLATION.

FIG. 17, E-22768A

CYLINDER LINER

General

There are two general categories of liners, and these can be classified by:

1. The exterior configuration which determines the manner in which the cooling water circulates around the liner. The two styles are generally referred to as the "belly-band" liner and the "annular-groove" (no belly-band) liner.

△Trademark of Kolene Corp.

†Product of Fiske Bros. Refining Co.

2. The treatment of the liner bore, namely, by "chrome-plating" or by "Tufftriding".

All belly-band liners were chrome-plated. Annular-groove liners were chrome-plated or Tufftrided.

Chrome-Plated Liner Inspection and Rework

1. Inspect the liner bore as follows:

NOTE: *The liner bore can be checked with the liner either in or out of the jacket.*

   a. Inspect the surface finish of the bore. Reject for scoring and wear thru the chrome plate.

   b. Measure the bore diameter and reject if, at any point measured, it exceeds 9.012 in.

   c. Check for out-of-roundness and a wear step in the piston ring reversal areas. Neither the out-of-roundness (measured on the diameter) nor the wear step (measured on the radius) may exceed 0.006 in.

NOTE: *To establish wear and out-of-roundness of liner bores, specified in Steps b and c above, determine the maximum and minimum bores in at least the following three planes:*

(1) At a distance of 1/8 to 1/4 in. from the top face of the liner
(2) In the upper piston ring reversal area
(3) At a distance of 1 in. below the upper piston ring reversal area.

2. Rework liner bores as follows:

   a. Blend out wear steps by re-honing with a diamond hone, providing the bore, after re-honing, does not exceed 9.012 in. It is not mandatory to entirely remove the wear step; it is permissible to remove only enough bore material to bring the wear step within the limit of 0.006 in.

   b. Liners may be diamond-honed to remove slight scoring or uneven wear, providing the finished bore does not exceed 9.012 in. Remove only the minimum amount of material to clean up the bore.

   c. Apply a matte finish to re-honed bores by grit blasting with aluminum oxide grit to achieve a 50-85 microinch finish.

3. Inspect the outside surface of the liner for corrosion. If corrosion is found, remove all indications.

4. Inspect the head-to-liner sealing surface for damage (nicks, scratches, corrosion, etc.). A 125C microinch finish is required on this surface. Refer to Fig. 18 for limits, and remove minimum material to clean up to the specified finish.

   For belly-band liners only, the top surface after machining cannot have dimension "A" less than 12.237 in. If it does, machine the clamp ring as shown in Fig. 18. Machining the step in the clamp ring allows additional machining of the liner top sealing surface until dimension "A" reaches 12.163 in., when the liner must be scrapped.

   For annular-groove liners, dimension "A" cannot be less than 12.237 in., since machining a step in the clamp ring will not permit the application of the square-cut jacket-to-liner water seal. Clamping rings used with belly-band liners must have the 12-degree chamfer increased to 32 degrees, as shown in Fig. 19.

   All clamping rings must have a 63-microinch finish on the surface contacting the clamping-ring bolt heads.

NOTE: *Special gages are available for measuring the cylinder-liner tang and the cylinder-head gasket groove. For details, refer to the Locomotive Maintenance Tools catalog, GEG-14700B.*

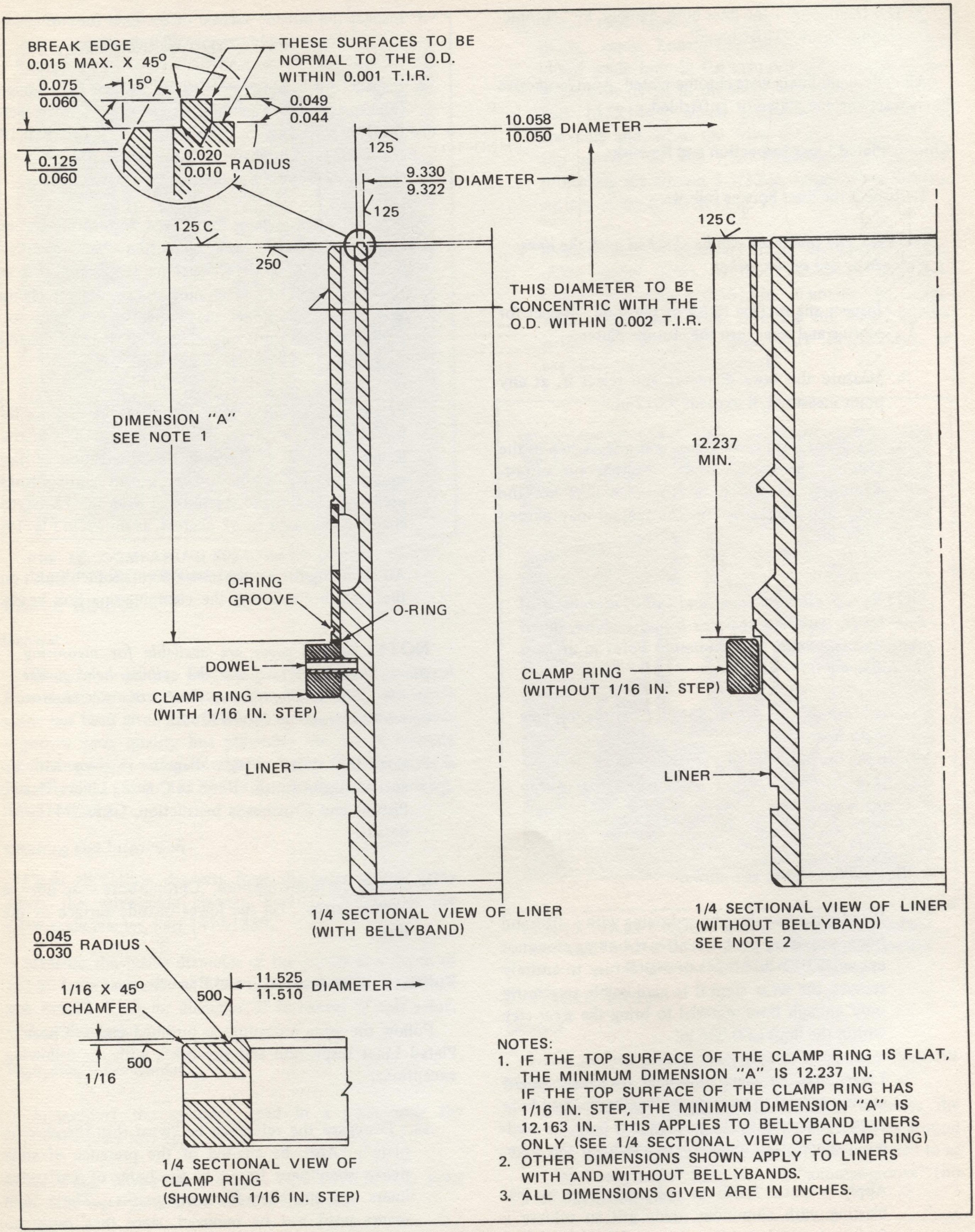
5. Coat the entire outside diameter surface with an anti-corrosion finish. Refer to Coating Liners, Heads, Pistons and Crossheads instruction, GEK-29411, for details.

6. Stencil the following note, "Chrome bore – do not use chrome rings", on the lower outside surface of the liner.

Tufftrided Liner Inspection and Rework

Follow the same procedure as outlined under "Chrome-Plated Liner Inspection and Rework", with the following exceptions:

1a. Disregard the reference to "wear thru the chrome plate". Also, be advised of the presence of stain marks sometimes found in the bores of Tufftrided liners and mistaken for score marks. These stain marks need not be removed, since they cause no improper cylinder function.


BREAK EDGE
0.015 MAX. X 45°
THESE SURFACES TO BE NORMAL TO THE O.D. WITHIN 0.001 T.I.R.
0.075/0.060
15°
0.049/0.044
0.125/0.060
0.020/0.010 RADIUS
10.058/10.050 DIAMETER
125
9.330/9.322 DIAMETER
125
125 C
250
THIS DIAMETER TO BE CONCENTRIC WITH THE O.D. WITHIN 0.002 T.I.R.
DIMENSION "A"
SEE NOTE 1
O-RING GROOVE
O-RING
DOWEL
CLAMP RING
(WITH 1/16 IN. STEP)
LINER
1/4 SECTIONAL VIEW OF LINER
(WITH BELLYBAND)
125 C
12.237
MIN.
CLAMP RING
(WITHOUT 1/16 IN. STEP)
LINER
1/4 SECTIONAL VIEW OF LINER
(WITHOUT BELLYBAND)
SEE NOTE 2
0.045/0.030 RADIUS
1/16 X 45°
CHAMFER
500
11.525/11.510 DIAMETER
500
1/16
1/4 SECTIONAL VIEW OF
CLAMP RING
(SHOWING 1/16 IN. STEP)
FIG. 18, E-16132B

NOTES:

1. IF THE TOP SURFACE OF THE CLAMP RING IS FLAT, THE MINIMUM DIMENSION "A" IS 12.237 IN. IF THE TOP SURFACE OF THE CLAMP RING HAS 1/16 IN. STEP, THE MINIMUM DIMENSION "A" IS 12.163 IN. THIS APPLIES TO BELLYBAND LINERS ONLY (SEE 1/4 SECTIONAL VIEW OF CLAMP RING)
2. OTHER DIMENSIONS SHOWN APPLY TO LINERS WITH AND WITHOUT BELLYBANDS.
3. ALL DIMENSIONS GIVEN ARE IN INCHES.

FIG. 18. LINER REWORK LIMITS.

FIG. 21, E-14993

FIG. 20, E-22727

FIG. 19, E-16545A

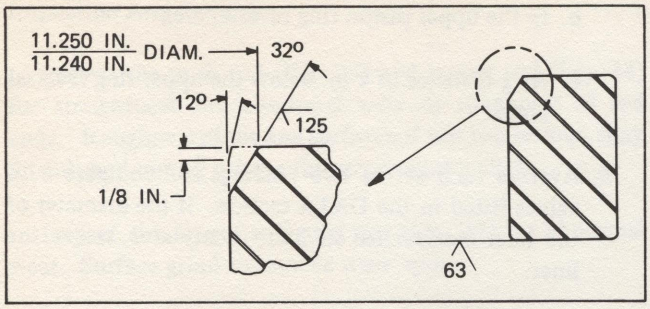


FIG. 19. CLAMPING RING MACHINING REQUIREMENTS (BELLYBAND LINERS ONLY).

2a, 2b. The use of a diamond hone is not mandatory; conventional honing stones are capable of accomplishing this rework operation.

The finish of the honed bore (Fig. 20) must meet the following requirements:

(1) The cross-hatch angle must be 27 to 33 degrees.
(2) The bore surface must be uniformly cut in both directions.
(3) The cross-hatch must be clean-cut but not sharp and must be free of torn or folded metal.
(4) Cross-hatch width to be 0.0002 to 0.0010 in. Cross-hatch depth to be 0.0001 to 0.0003 in.
(5) Plateau area to be 1/2 to 2/3 of total surface area.
(6) Bore must be free of burnished or glazed metal.
(7) Bore must be free of imbedded particles.

NOTE: *The above-specified finish is achieved at the factory using a honing tool equipped with six 100-grit stones and two 80-grit stones.*

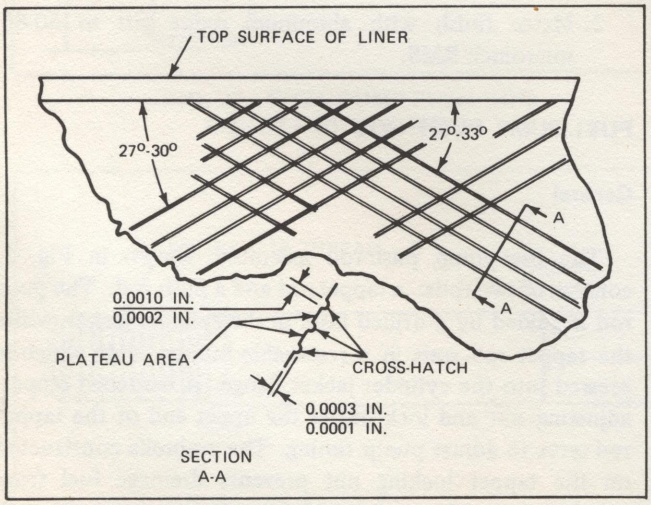


FIG. 20. FINISH OF HONED BORE IN TUFFTRIDED LINER.

2c. Application of the matte finish is not required with Tufftrided liners.

4. Disregard all references to belly-band liners, since all Tufftrided liners are of the annular-groove type.

6. Stencil the following note, "Use chrome-plated rings only", on the lower outside surface of the liner.

Measuring Liner Bore Size

Liner bore size is most accurately measured by using the dial bore gage, Part 147X1030 (Fig. 21). It is calibrated in a standard ring gage, Part 147X1031 (Fig. 22).

CAUTION: *THE BORE GAGE IS A PRECISION INSTRUMENT AND MUST BE HANDLED WITH CARE.*

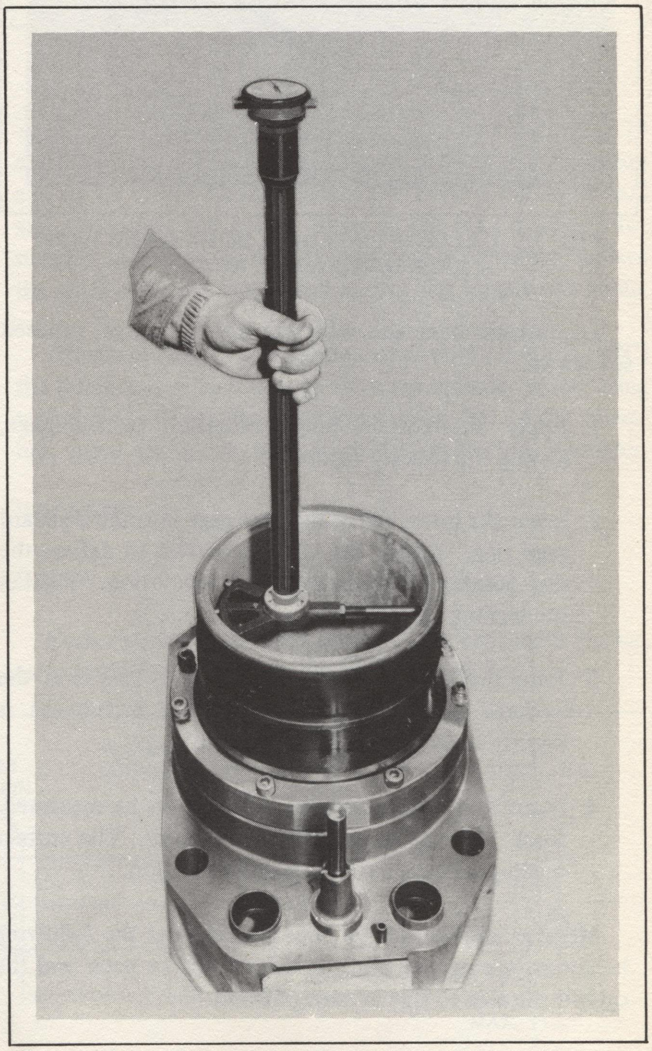


FIG. 21. MEASURING CYLINDER LINER BORE DIAMETER.

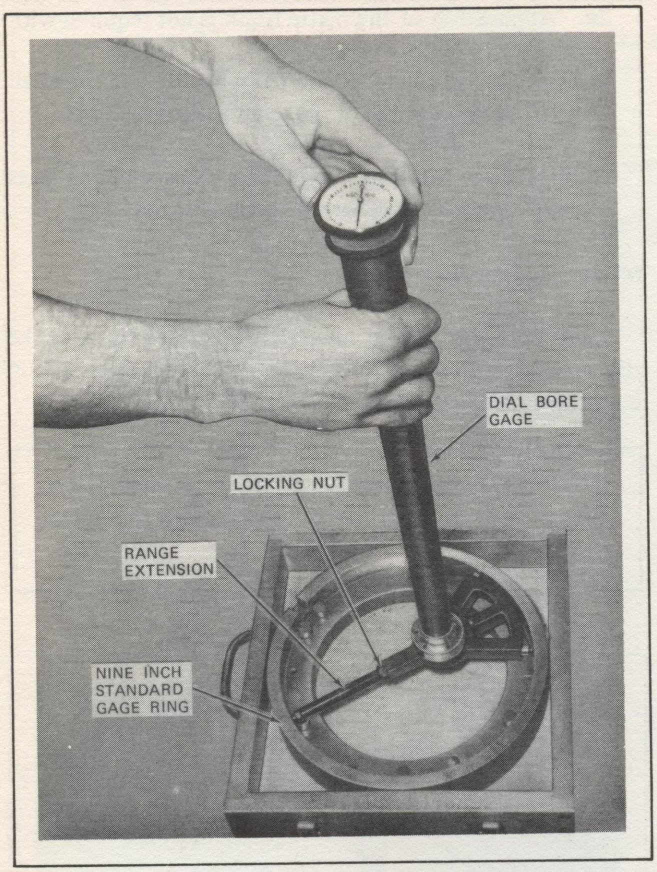


FIG. 22. CALIBRATING DIAL BORE GAGE WITH A STANDARD GAGE RING.

FIG. 22, E-10019

To measure liner size with the dial bore gage, proceed as follows:

1. Apply the correct range extension to the gage, leaving the locking nut loose.
2. Insert the lower end of the bore gage into the standard gage ring. Adjust the range extension to deflect the dial pointer approximately one revolution. Tighten the locking nut.
3. Turn the dial bezel so that the zero line is at the extreme pointer position when the instrument is slightly rocked in the standard gage ring.
4. Insert the bore gage into the liner to be measured. Rock the gage back and forth slightly. The correct reading is at the extreme pointer position.

Measure and record the bore diameters at the following locations, taking one reading from front to back and the other from side to side at each position:

a. At a distance of 1/8 to 1/4 in. from the top face of the liner

b. In the upper piston ring reversal area

c. At a distance of 1 in. below the upper ring reversal area.

5. Average each set of two readings and compare with values listed in the DATA section. If the diameter of the liner has reached its limit in any area, renew the liner.

Replating Requirements

Preparation For Plating

1. Chrome which is worn, but not less than 0.003 in. thick at any point: Re-hone to clean up the bore and at least 0.005 in. greater than the finished bore dimension. Grit blast to 50-100 RMS finish.
2. Chrome which is worn through or to less than 0.003 in. thick at some point: De-plate to the base metal, hone out the step, if any, and grit blast to 150-250 RMS finish.

Plating

Dense chromium – minimum hardness, 900 Knoop with 100-gram load. Thickness to be enough so that all of the surface area of the bore will be cleaned up by honing to the finished bore size. Minimum radial thickness of the plate, 0.006 in.

Finishing (After Plating)

1. Diamond hone to 9.000-9.003 in. diameter.
2. Matte finish with aluminum oxide grit to 50-85 microinch RMS.

FUEL-PUMP PUSH ROD

General

The fuel-pump push-rod assembly, shown in Fig. 2, consists of two rods: a tappet rod and a push rod. The push rod is guided by a drilled bore in the cylinder jacket, while the tappet rod runs in a renewable bronze guide which is pressed into the cylinder jacket flange. A hardened tappet-adjusting nut and lock nut at the upper end of the tappet rod serve to adjust pump timing. The umbrella constructed on the tappet locking nut prevents drainage fuel from running down the tappet rod into the crankcase through the guide.

Inspection And Rework

Inspect the push rod (Fig. 23) and tappet rod (Fig. 24) for straightness and abnormal wear or roughness of rod ends. Roughness of the end surfaces, if not too serious, may be polished out by using a fine-grade emery cloth.

Inspect the tappet adjusting nut (Fig. 25) for abnormal wear. Surface grind to remove worn spot.

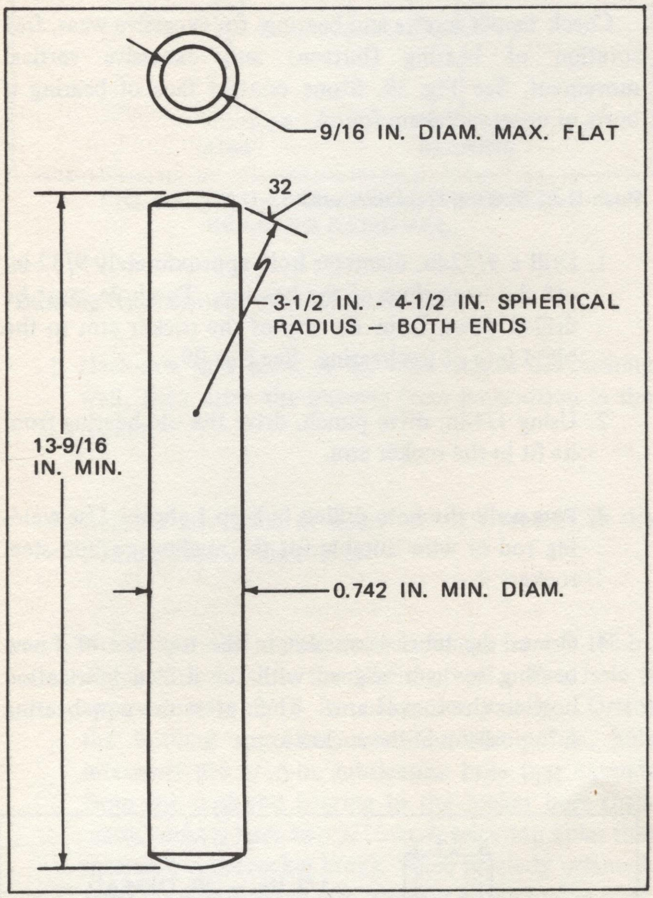

9/16 IN. DIAM. MAX. FLAT
32
3-1/2 IN. - 4-1/2 IN. SPHERICAL RADIUS – BOTH ENDS
13-9/16 IN. MIN.
0.742 IN. MIN. DIAM.

FIG. 23. FUEL-PUMP PUSH-ROD CONDEMNING LIMITS.

FIG. 23, E-22731

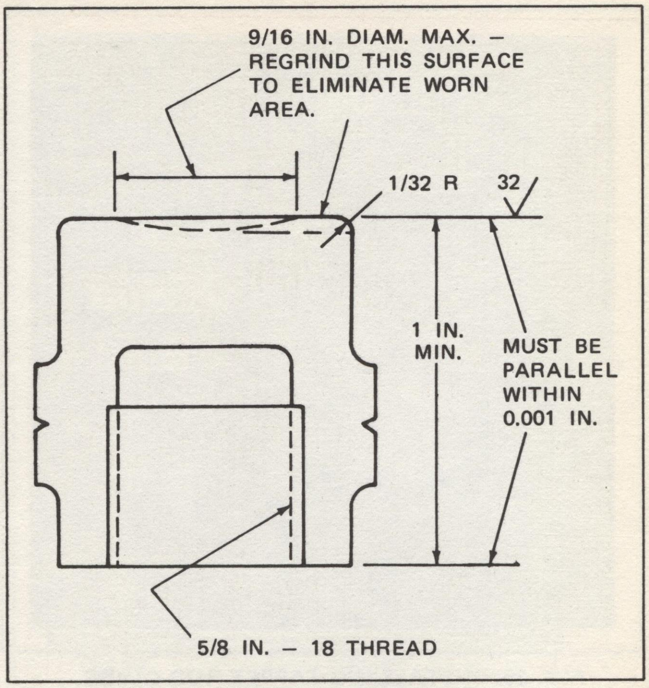

9/16 IN. DIAM. MAX. – REGRIND THIS SURFACE TO ELIMINATE WORN AREA.
1/32 R
32
1 IN. MIN.
MUST BE PARALLEL WITHIN 0.001 IN.
5/8 IN. – 18 THREAD

FIG. 25. TAPPET ADJUSTING NUT CONDEMNING LIMITS.

FIG. 25, E-22732

Check the bearing diameters for minimum limits (Fig. 23 and 24). Check for running clearance between the push rod and its fit in the cylinder jacket and betwen the tappet rod and the tappet rod guide. Refer to the DATA section for running clearance limits. If clearance is excessive, replace the push rod, the tappet rod and/or the tappet rod guide.

When applying a new guide, super cool (-160F/-107C) the guide and drive it into its fit in the cylinder jacket using tappet-guide driver, Part 147X1443 (Fig. 26). After assembly, ream the guide bore to 0.7505/0.7495-in. diameter.

ROCKERS

General

Each cylinder has three rockers: an inlet-valve rocker, an exhaust-valve rocker, and a bell-crank rocker.

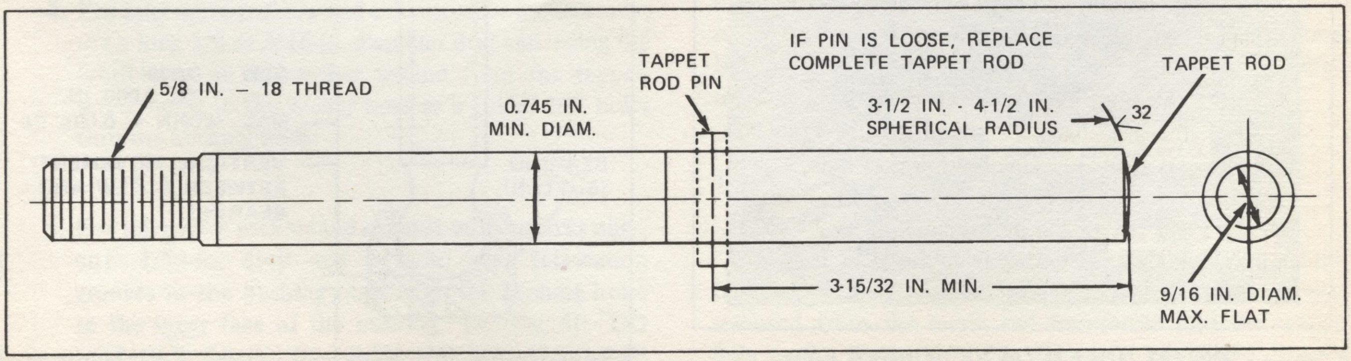

5/8 IN. – 18 THREAD
0.745 IN. MIN. DIAM.
TAPPET ROD PIN
IF PIN IS LOOSE, REPLACE COMPLETE TAPPET ROD
TAPPET ROD
3-1/2 IN. - 4-1/2 IN. SPHERICAL RADIUS
32
3-15/32 IN. MIN.
9/16 IN. DIAM. MAX. FLAT

FIG. 24. FUEL-PUMP TAPPET-ROD CONDEMNING LIMITS.

FIG. 24, E-13341A

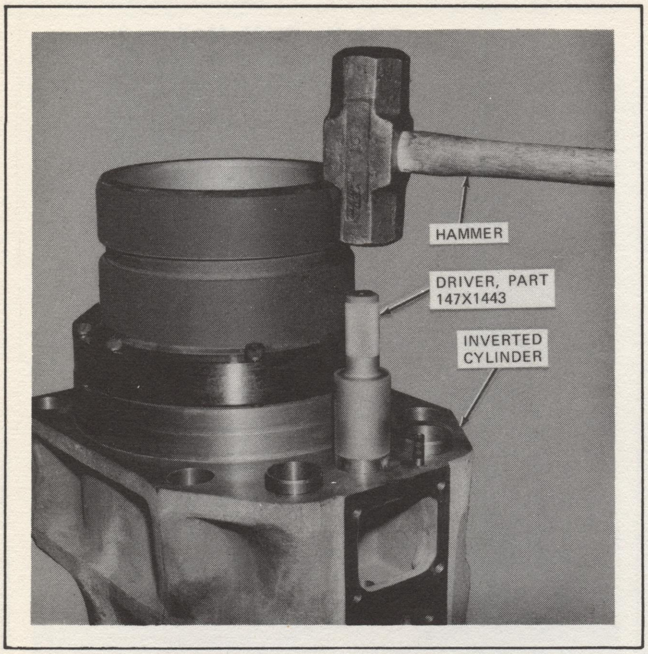

HAMMER
DRIVER, PART 147X1443
INVERTED CYLINDER

FIG. 26. INSTALLING TAPPET ROD GUIDE.

Lubrication for rocker bushings, push-rod bearings and tappet-screw bearings is supplied thru the two valve push rods then thru a network of holes in the rockers, in the cross-over push rod, and grooves in the rocker bushings, to all bearing surfaces.

Two general styles of rockers have been used. The old style rockers used flanged, bronze bushings; the new, current-production style (Fig. 27) uses steel-backed, bronze-faced, flange-less bushings. Old-style bushings are available to repair old rockers, but the old-style rocker, as a complete assembly, has been superseded by the new-style rocker assembly.

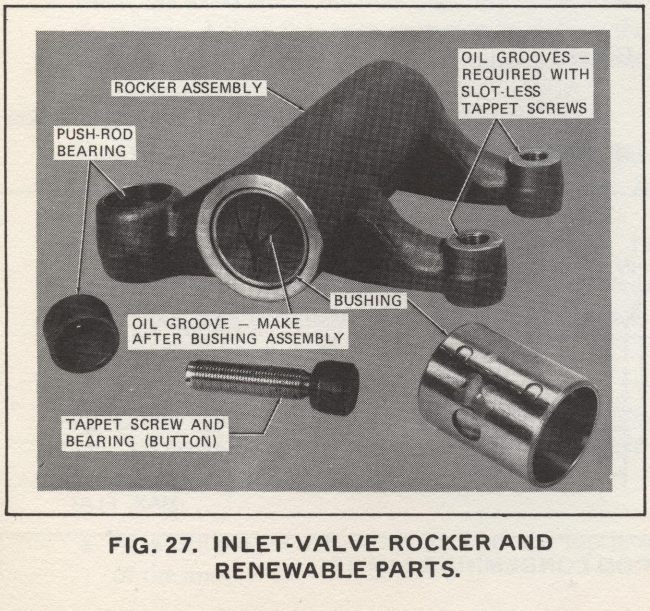

ROCKER ASSEMBLY
OIL GROOVES – REQUIRED WITH SLOT-LESS TAPPET SCREWS
PUSH-ROD BEARING
BUSHING
OIL GROOVE – MAKE AFTER BUSHING ASSEMBLY
TAPPET SCREW AND BEARING (BUTTON)

FIG. 27. INLET-VALVE ROCKER AND RENEWABLE PARTS.

Inspection

Check the rocker for indications of cracks, using Magnaflux testing equipment. If found, grind out and polish. Maximum depth of repairable crack is 1/32 in.; maximum aggregate length of all cracks in one rocker is 1/2 in. Check for loose, galled or cracked push-rod bearings. If found, replace with new bearings.

Check for excessively worn or damaged bushings and replace, if found, with new bushings.

Check tappet screws and bearings for excessive wear, free rotation of bearing (button) and excessive vertical movement. See Fig. 28. Stone contact face of bearing if burrs or upset metal are found.

Push-Rod Bearing Replacement

1. Drill a 9/32-in. diameter hole approximately 9/32-in. off the centerline of the bearing. The hole must be drilled down from the top of the rocker arm to the blind face of the bearing. See Fig. 29.
2. Using 1/4-in. drive punch, drive the old bearing from its fit in the rocker arm.
3. Plug-weld the hole drilled in Step 1 above. Use welding rod or wire suitable for the medium-carbon steel rockers.
4. Orient the lubrication slot in the top face of a new bearing so it is aligned with the drilled lubrication hole in the rocker arm. Then press the new bearing into position in the rocker arm.

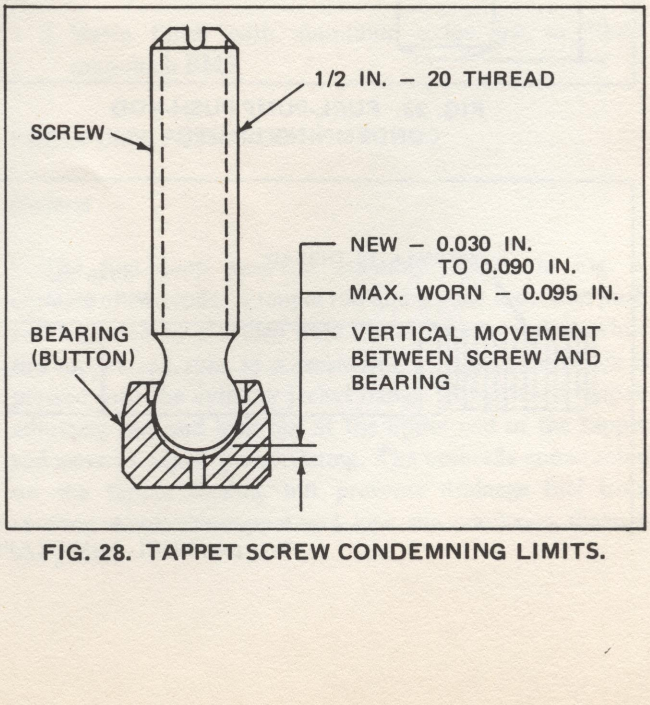

1/2 IN. – 20 THREAD
SCREW
NEW – 0.030 IN. TO 0.090 IN.
MAX. WORN – 0.095 IN.
BEARING (BUTTON)
VERTICAL MOVEMENT BETWEEN SCREW AND BEARING

FIG. 28. TAPPET SCREW CONDEMNING LIMITS.

FIG. 28, E-22745

FIG. 27, E-22761A

FIG. 26, E-22769

FIG. 30, E-22747A

FIG. 29, E-22746

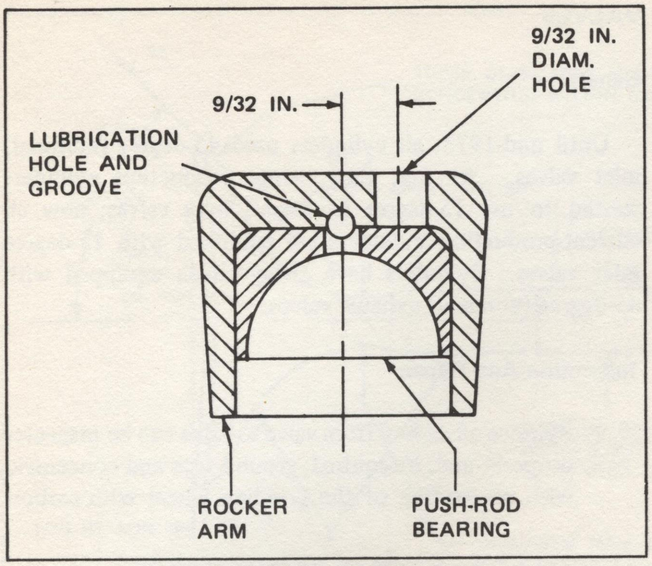

9/32 IN. DIAM. HOLE
9/32 IN.
LUBRICATION HOLE AND GROOVE
ROCKER ARM
PUSH-ROD BEARING

FIG. 29. DRILLING INSTRUCTION FOR BEARING REMOVAL.

Bushing Replacement (New Style Rocker)

1. Hack-saw thru most of the thickness of the bushing wall, then drive the bushing from its position in the rocker.

2. Remove any burrs or upset metal, if present, in the bushing bore of the rocker.

3. Note that new replacement bushings have a 1/2-in. diameter hole thru the bushing wall. This hole is approximately 3/16 in. off-center axially. Orient the bushing so, after assembly, the 1/2-in. hole intersects the 3/16-in. lubrication hole that extends from the push-rod bearing to the rocker bore (bell-crank rockers have two 3/16-in. lubrication holes that intersect at the rocker bore). When properly oriented, press the new bushing into position in the rocker bore.

4. For inlet-valve rockers and exhaust-valve rockers only, use a long 1/8 or 3/16-in. diameter drill and, using the lubricating oil holes that extend from the tappet-screw holes to the rocker bore as a guide, drill holes thru the bushing walls.

5. For inlet-valve rockers and exhaust-valve rockers only, cut 1/32-in. deep and 1/16-in. wide lubrication grooves in the bushing bore from the bushing holes to the inner face of the bushing. See Fig. 30. DO NOT CUT GROOVES FROM THE HOLES TO THE OUTER FACES OF THE BUSHING.

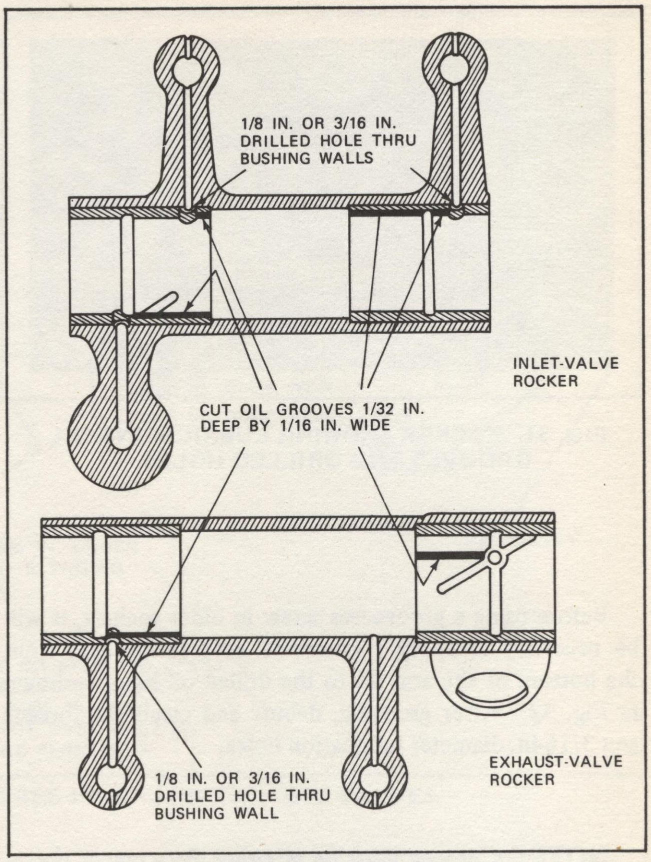

1/8 IN. OR 3/16 IN. DRILLED HOLE THRU BUSHING WALLS
INLET-VALVE ROCKER
CUT OIL GROOVES 1/32 IN. DEEP BY 1/16 IN. WIDE
EXHAUST-VALVE ROCKER
1/8 IN. OR 3/16 IN. DRILLED HOLE THRU BUSHING WALL

FIG. 30. OIL PASSAGES APPLIED AFTER BUSHING ASSEMBLY.

6. Hone bore to 1.5005/1.5015 in. diameter with a 32 microinch finish.

7. Deburr and clean to remove all dirt and abrasive material.

Bushing Replacement (Old Style Rocker)

Renewing rockers using the flanged bushing, Part 124X-1001, is not recommended because of cost considerations. Since a bushing replacement involves replacement of push-rod bearings, in addition to the bushings, and extensive machining labor, it has been found more economical to replace worn old-style rockers with the new-style rockers. Refer to the Renewal Parts bulletin for appropriate superseded rocker part numbers.

Tappet-Screw Lubrication

Originally, tappet screws had a lubrication groove cut the full length of the thread. Since 1965 the oil groove was removed from the screw and transferred into the tapped hole in the rocker arm (Fig. 31) so it connected directly with the drilled oil hole.

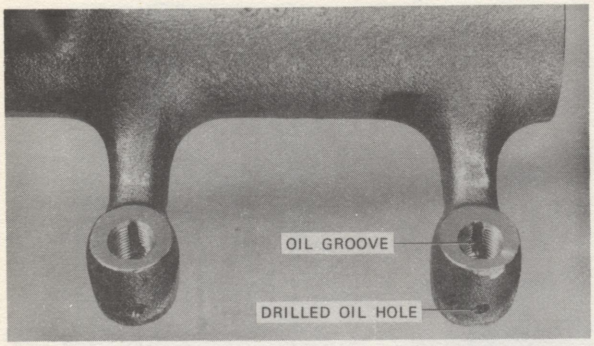


FIG. 31. ROCKER SHOWING LUBRICATING-OIL GROOVES AND DRILLED HOLES.

Before using a groove-less screw in older rockers, it will be necessary to apply a groove to each rocker arm from the bottom of the arm up to the drilled oil hole, as shown in Fig. 32. After grooving, deburr and clean the threads and 3/16-in. diameter lubrication holes.

NOTE: *A groove must be in either the screw or the tapped hole in the rocker arm to provide lubrication to the ball-mounted bearing (button) on the lower end of the screw. Combining a slotted screw and grooved tapped hole does no harm.*

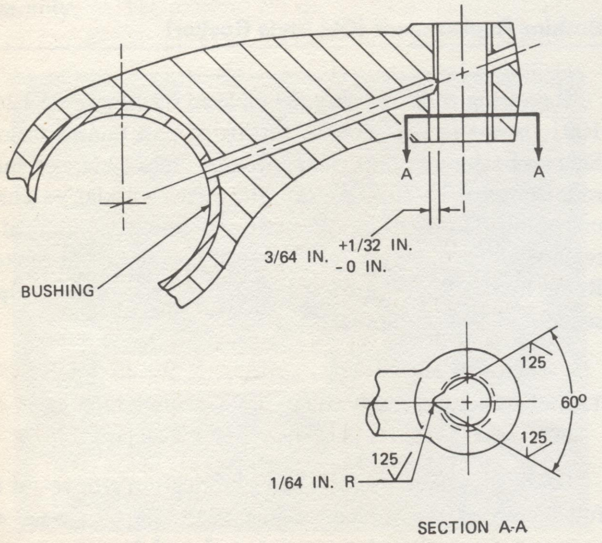


FIG. 32. OIL-GROOVE DETAILS FOR INLET-VALVE AND EXHAUST-VALVE ROCKERS.

VALVES

General

Until mid-1973, all cylinders used 45-degree (nominal) inlet valves. At that time, some production cylinders started to use 15-degree (nominal) inlet valves; now all current-production cylinders are equipped with 15-degree inlet valves. Cylinders have always been equipped with 45-degree (nominal) exhaust valves.

Inspection And Repair

1. Remove all carbon from valve so valve can be inspected properly and, if required, ground true and concentric, with no loading of the grinding wheel with carbon.

2. Zyglo* check valve for presence of cracks.

3. Dimensionally check valve. Refer to Fig. 33 and 34 or 35.

4. Grind the valve face in the following manner:

    a. Place the stem in the valve-grinding machine so the chuck grips the straight-diameter portion of the valve stem.

    b. Grind the valve face to the correct angle (Fig. 34 or 35). When grinding is complete, the valve face must run concentric to the stem and must be free of chatter marks, pits and concentric grooves.

5. Square off and reface the tappet end of the valve stem by grinding.

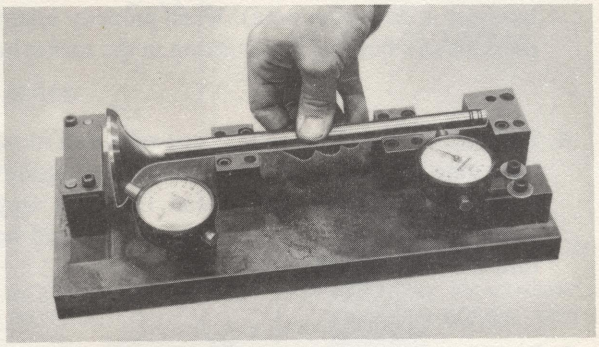


FIG. 33. CHECKING VALVE IN VALVE-CHECKING FIXTURE, PART 147X1679-1.

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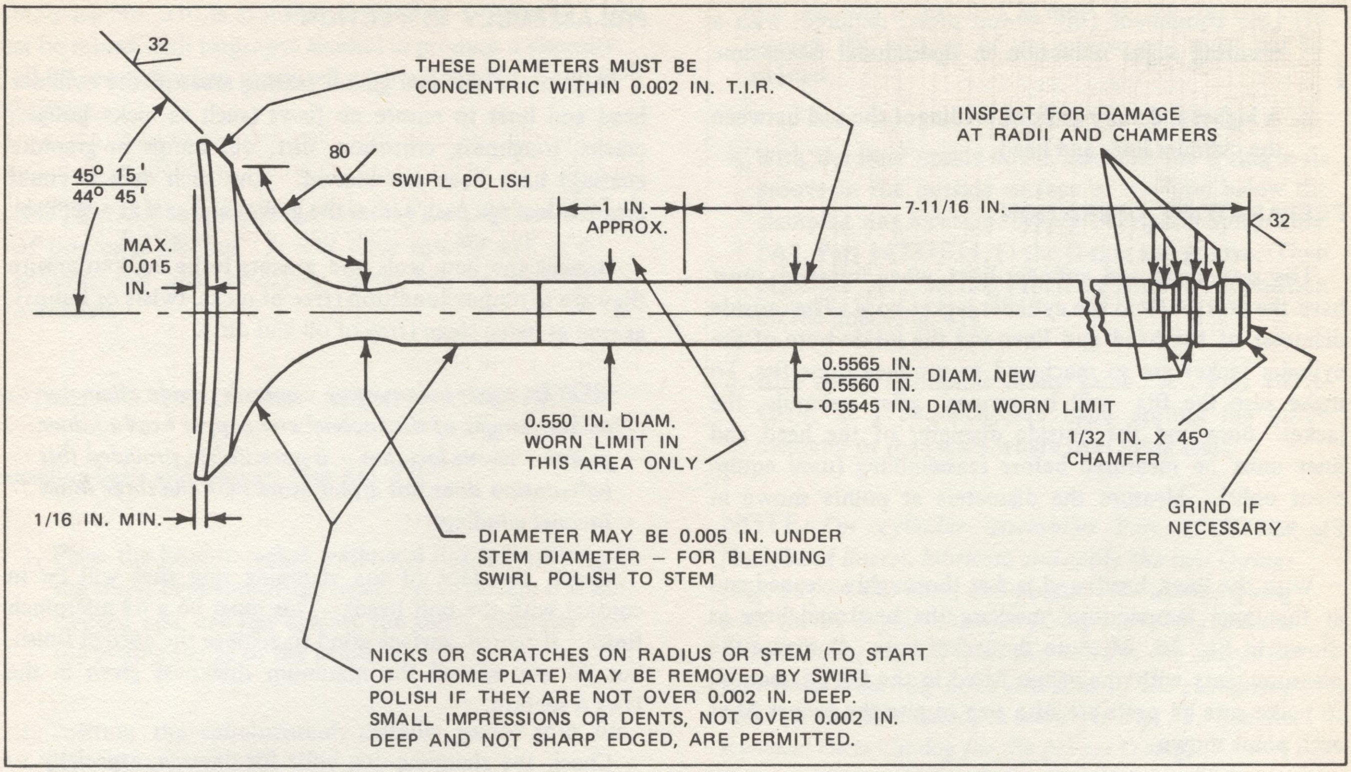
*Product of Magnaflux Corp.

FIG. 33, E-20906

FIG. 32, E-22335A

FIG. 31, E-22334

FIG. 34, E-22743



THESE DIAMETERS MUST BE CONCENTRIC WITHIN 0.002 IN. T.I.R.

INSPECT FOR DAMAGE AT RADII AND CHAMFERS

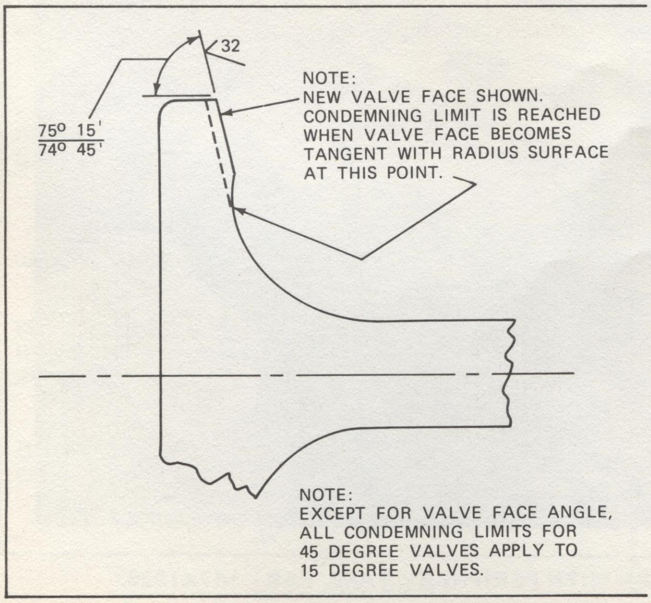
DIAMETER MAY BE 0.005 IN. UNDER STEM DIAMETER – FOR BLENDING SWIRL POLISH TO STEM

NICKS OR SCRATCHES ON RADIUS OR STEM (TO START OF CHROME PLATE) MAY BE REMOVED BY SWIRL POLISH IF THEY ARE NOT OVER 0.002 IN. DEEP. SMALL IMPRESSIONS OR DENTS, NOT OVER 0.002 IN. DEEP AND NOT SHARP EDGED, ARE PERMITTED.

FIG. 34. CONDEMNING LIMITS FOR 45-DEGREE INLET AND EXHAUST VALVES.

NOTE: *Do not rework exhaust valves with date stamp (on the face of the valve head) prior to 8-68, or with no date stamp. These valves should be scrapped since they are of questionable quality and could cause serious damage to the engine in the event of valve failure.*

FIG. 35, E-22744



NOTE:
NEW VALVE FACE SHOWN. CONDEMNING LIMIT IS REACHED WHEN VALVE FACE BECOMES TANGENT WITH RADIUS SURFACE AT THIS POINT.

NOTE:
EXCEPT FOR VALVE FACE ANGLE, ALL CONDEMNING LIMITS FOR 45 DEGREE VALVES APPLY TO 15 DEGREE VALVES.

FIG. 35. CONDEMNING LIMITS FOR 15-DEGREE INLET VALVES.

INSTALLING HEAD AND LINER INTO JACKET

GENERAL

Two methods of assembling the head and liner into the jacket have been used to produce reliable cylinder assemblies. These will be detailed below. The original method, termed "Method A", was used in our factory for several years and involved the use of an oven for heating the jacket to a temperature of 325F (163C), a press capable of producing a 40-ton (355 858 N) force, suitable measuring and lifting tools, and a torque wrench for tightening the clamping-ring bolts to a value of 85-90 lb.-ft. (115-122 N•m) with jacket hot and 70-75 lb.-ft. (95-102 N•m) with jacket cold.

The new method, termed "Method B" and used in our factory since mid-1975, requires an oven for heating the jacket to a temperature of 350F (177C), no press, the same measuring and lifting tools used in "Method A", and a torque wrench for tightening the clamping-ring bolts to a value of 85-90 lb.-ft. (115-122 N•m) with jacket hot and 95-100 lb.-ft. (129-136 N•m) with jacket cold.

While both methods have the capability of producing reliable cylinder assemblies, "Method B" has two additional benefits when compared to "Method A":

1. Less equipment (the 40-ton press) required, with a resulting slight reduction in operational labor time
2. A higher and more-uniform loading of the seal between the cylinder liner and head.

PREPARATORY OPERATION

The steel head and cylinder liner, when installed, must have the correct fit in the cylinder-jacket bore. The outside diameter of the head and liner and the inside bore of the cylinder jacket are so machined to produce these fits. To make sure the fits will be proper after assembly, the jacket bore and the outside diameter of the head and liner must be measured before reassembling (used equipment only). Measure the diameters at points shown in Fig. 9.

With the liner, head, and jacket thoroughly cleaned and at the same temperature, measure the head and liner as shown in Fig. 36. Measure the jacket bore. Compare the measurements with the values listed in the DATA section, to make sure all parts are of a size to give the proper fit at each point shown.

CAUTION: *Do not install a head or liner to the jacket without the proper fit.*

PRE-ASSEMBLY INSPECTION

Inspect the seal and gasket seating areas of the cylinder head and liner to ensure no flaws (such as nicks, gouges, cracks, roughness, corrosion, dirt, oil, lumps or graphite coating) have been overlooked. Any such defects could create a leakage path across the gasket and seal at assembly.

Inspect the new seals and gaskets to be used to ensure they are in proper condition (free of nicks, twists or lumps), as well as being clean (free of oil and dirt).

NOTE: *One indentation on both inside diameter gasket flanges of the Inconel and copper head-to-liner gasket – at one location – is permissible, provided this indentation does not affect more than the three inner Inconel windings.*

Check the face of the clamping ring that will be in contact with the bolt heads. This must be a 63 microinch finish. If scored, surface grind to achieve the correct finish, but do not exceed the minimum thickness given in the DATA section.

Check the clamping-ring bolts for damage, especially to the threads, and for galling under the bolt head. If reusable, clean the bolts thoroughly and dip in a Molydag* No. 210 solution. Allow to air dry. The threads and undersides of the bolt heads must be covered with this lubricant before using.

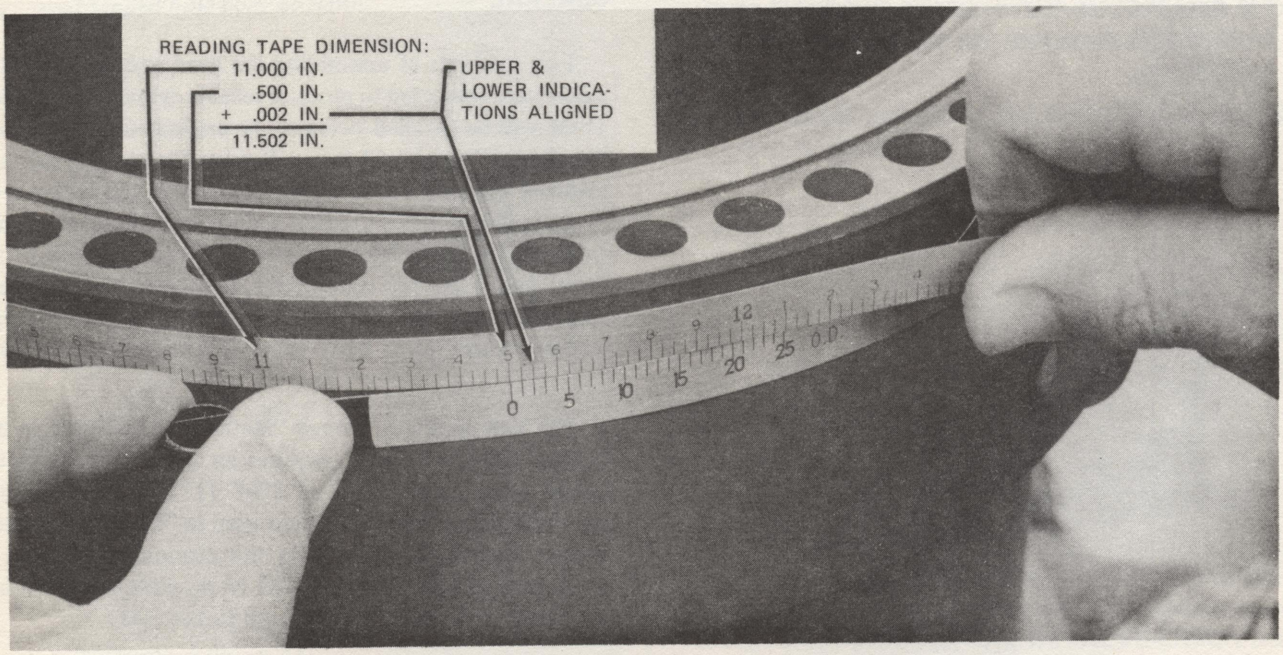


FIG. 36. MEASURING LINER OUTSIDE DIAMETER WITH PERIPHERY TAPE, PART 147X1029.

FIG. 36, E-22730

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*Product of Acheson Colloids Co.

Molydag No. 210 is available as GE Part 147X1613. It must be mixed with isopropyl alcohol to produce a viscosity of 60-90 seconds when measured with a Zahn No. 1 cup at 77F (25C).

NOTE: *Normal propyl alcohol may be used instead of isopropyl alcohol. It will serve equally well as a solvent, but the air-drying time will be slightly extended.*

INSTALLING HEAD AND LINER – "METHOD A"

Installing Seals and Gaskets (See Fig. 37)

1. Place the head-to-jacket water seal ring in position on the outer diameter of the head. Make certain it is not twisted and lies flat against the outer diameter and the sealing flange of the head.

2. Position the spiral-wound, metallic gasket into the groove.

3. Gently stretching the seal ring with both hands, work it into the space between the gasket and the outer land of the gasket groove. It will be necessary to keep pressing it down solidly into the bottom of the gasket groove so it will not roll up over the outer "V" of the gasket and pop out of position. After the seal ring is installed, it must remain flat and snug against the bottom of the groove and must not be twisted.

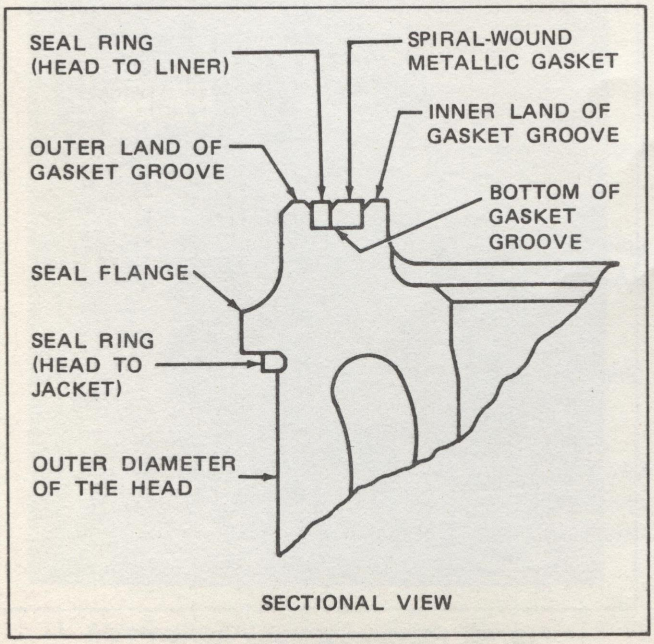

SEAL RING (HEAD TO LINER)
SPIRAL-WOUND METALLIC GASKET
INNER LAND OF GASKET GROOVE
OUTER LAND OF GASKET GROOVE
BOTTOM OF GASKET GROOVE
SEAL FLANGE
SEAL RING (HEAD TO JACKET)
OUTER DIAMETER OF THE HEAD
SECTIONAL VIEW

FIG. 37. CYLINDER-HEAD SEALS AND GASKETS.

4. With the liner upside down, assemble the O-ring in its groove in the outside surface of the liner below the clamping ring location. Apply Lubriplate Spray Lube "A", Part 147X1614, to the O-ring and groove. Then place the clamping ring with the eight bolts in position on the liner (Fig. 41).

5. Also spray Lubriplate Spray Lube "A", Part 147X-1614, in a two-inch-wide band around the inside diameter of the jacket where the O-ring seats.

NOTE: *On cylinder assemblies Part 121X1100 (bellyband liners), lubricate and apply the two O-rings (Fig. 18) on the liner, and position the clamping ring with the 32-degree chamfer facing the O-ring and the roll pin holes aligned with the holes in the liner. The four head mounting bolts and four of the clamp ring bolts can be eliminated, as shown in Fig. 38. See the Renewal Parts Catalog for the proper O-rings.*

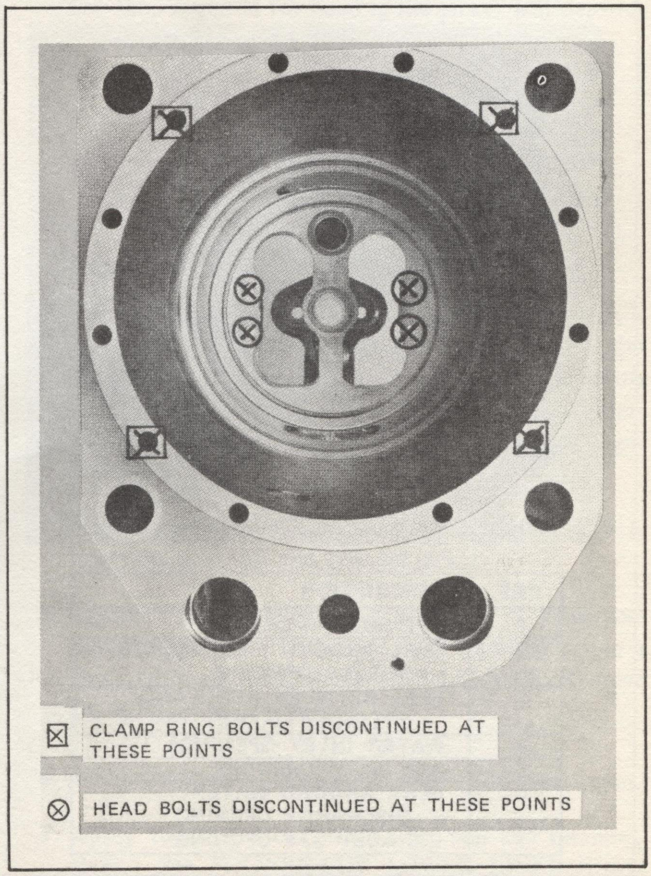

☒ CLAMP RING BOLTS DISCONTINUED AT THESE POINTS
⊗ HEAD BOLTS DISCONTINUED AT THESE POINTS

FIG. 38. ORIGINAL THREE-PIECE CYLINDER JACKET.

FIG. 37, E-15066A
FIG. 38, E-16544

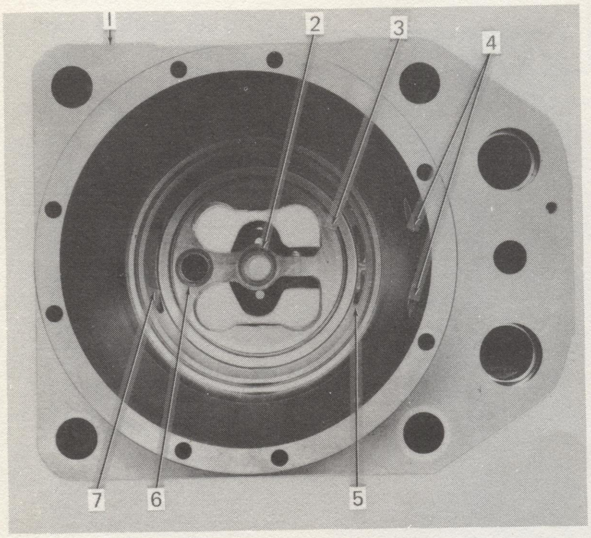
Installing Head and Liner

1. Place the cylinder jacket, with the open end up, in an oven, and heat it to approximately 325F (163C). Three to four hours are generally required to obtain the temperature.

NOTE: *Steps 2 through 6 should be performed as quickly as possible to take full advantage of the existing temperature differential between the jacket and the head and liner.*

2. Remove the jacket and place the injector nozzle seal, the water discharge seal, and the head-to-jacket seal in the recesses in the cylinder jacket. See Fig. 39.

3. Using cylinder-head lifter, Part 147X2024 (Fig. 40), lower the head into the jacket, making sure the compression release hole in the head is aligned with its respective opening in the jacket. Use cylinder-head aligner, Part 147X1673, to ensure proper alignment.



REF.	DESCRIPTION
1	CYLINDER JACKET
2	SEAL AROUND FUEL-INJECTOR NOZZLE OPENING
3	SEAL BETWEEN HEAD AND CYLINDER JACKET
4	WATER INLET OPENINGS
5	AIR INLET OPENING
6	SEAL AROUND WATER DISCHARGE OPENING
7	EXHAUST GAS OPENING

FIG. 39. VIEW OF OPEN END OF CYLINDER JACKET.

4. Using cylinder-liner lifter, Part 147X1646 (Fig. 41), lower the liner into the cylinder jacket.

5. Position the assembly in the press, and with a plate over the end of the liner, apply 40 tons pressure against the liner.

6. With the 40-ton pressure applied, tighten the clamping-ring bolts in a criss-cross pattern. Increase the torque in increments up to a final value of 85-90 lb.-ft. (115-122 N·m). Remove the cylinder-head aligner.

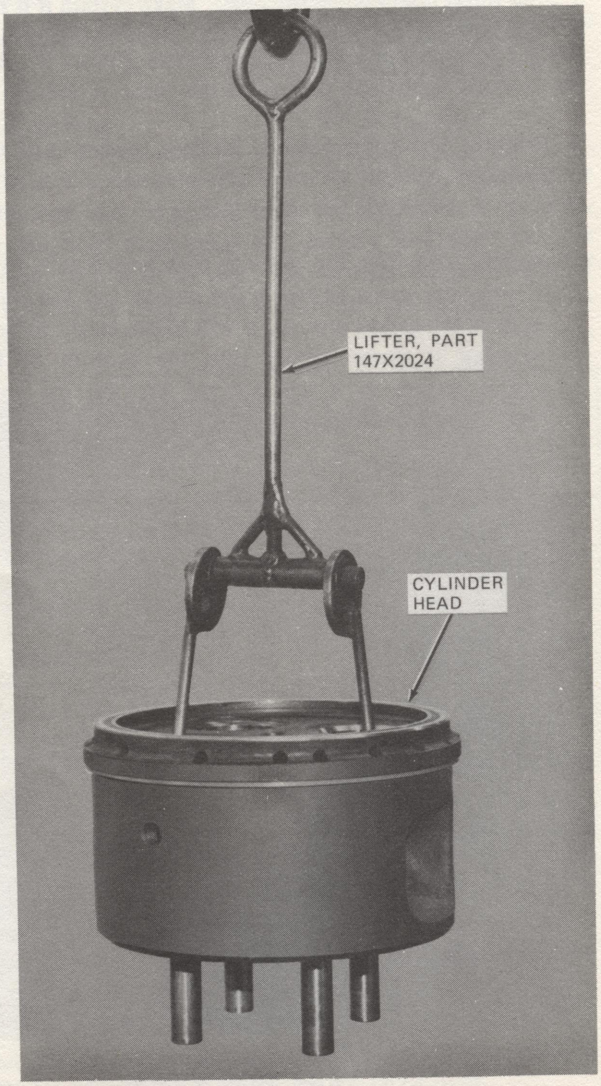


FIG. 40. HEAD ASSEMBLY READY FOR INSTALLATION IN CYLINDER JACKET.

FIG. 40, E-22766

FIG. 39, E-14988

FIG. 41, E-20968A

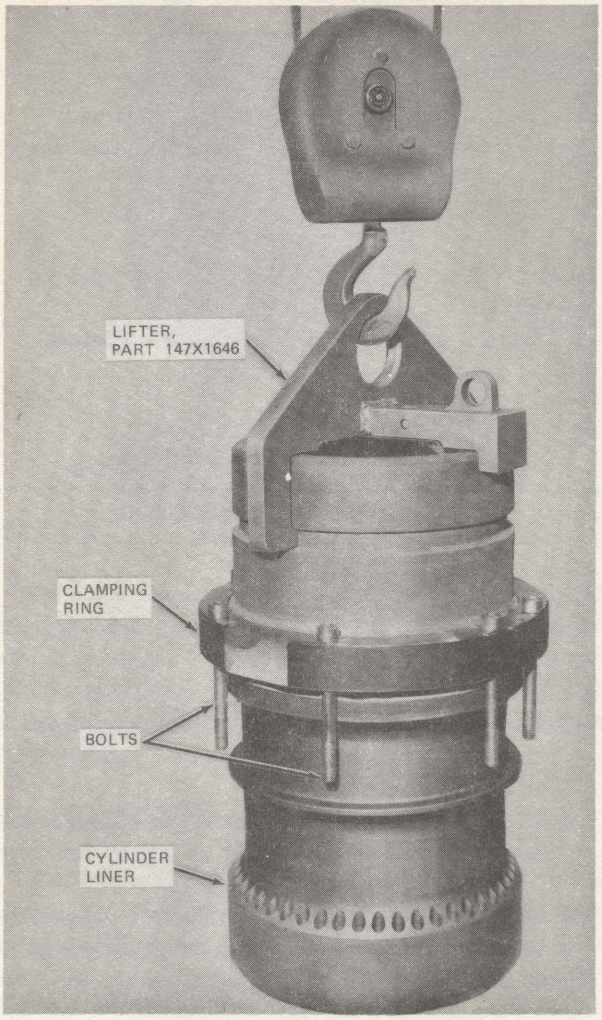


FIG. 41. LINER AND CLAMPING RING READY FOR INSTALLATION IN CYLINDER JACKET.

7. Remove the press load and allow the assembly to cool to 100F (38C) maximum.

8. Apply the square-cut lower liner seal and retaining rings. See SQUARE-CUT LOWER LINER SEAL section.

9. Retighten the clamping-ring bolts to a torque value of 70-75 lb.-ft. (95-102 N•m).

10. Measure the space between the cylinder liner and the cylinder head. This space must be less than 0.0015 in. (0,038 mm) around the full circumference.

11. Install the compression release valve. Refer to COMPRESSION RELEASE VALVE section.

12. Apply air test to cylinder assembly. See AIR TESTING CYLINDER section.

13. Apply high-pressure hydraulic test to cylinder assembly. See HYDRAULIC TESTING CYLINDER section.

14. Grind all valve seats. See VALVE SEATS, Grinding Valve Seats section.

15. Clean the cylinder assembly and make certain all traces of abrasive material are removed.

INSTALLING HEAD AND LINER – "METHOD B"

Installing Seals and Gaskets

Follow the same procedure outlined under "Method A."

Installing Head and Liner

1. Install the injector nozzle seal, the water discharge seal, and the head-to-jacket seal in the recesses in the cylinder jacket. See Fig. 39.

2. Place the cylinder jacket, with the open end up, in an oven, and heat it to 300F to 350F (149C to 177C). The time required for heating the jacket will depend on the capacity of the oven.

NOTE: *Steps 3 through 5 should be performed as quickly as possible to take full advantage of the existing temperature differential between the jacket and the head and liner.*

3. Using cylinder-head lifter, Part 147X2024 (Fig. 40), lower the head into the jacket, making sure the compression release hole in the head is aligned with its respective opening in the jacket. Use cylinder-head aligner, Part 147X1673, to ensure proper alignment.

4. Using cylinder-liner lifter, Part 147X1646 (Fig. 41), lower the liner into the cylinder jacket.

5. Tighten the clamping-ring bolts in a criss-cross pattern. Increase the torque in increments up to a final value of 85-90 lb.-ft. (115-122 N·m). Remove the cylinder-head aligner.

6. Allow the assembly to cool to 100F (38C) maximum.

7. Apply the square-cut lower liner seal and retaining rings. See SQUARE-CUT LOWER LINER SEAL section.

8. Retighten the clamping-ring bolts to a torque value of 95-100 lb.-ft. (129-136 N•m).

9. Measure the space between the cylinder liner and the cylinder head. This space must be less than 0.0015 in. (0,038 mm) around the full circumference.

10. Install the compression release valve. Refer to COMPRESSION RELEASE VALVE section.

11. Apply air test to cylinder assembly. See AIR TESTING CYLINDER section.

12. Apply high-pressure hydraulic test to cylinder assembly. See HYDRAULIC TESTING CYLINDER section.

13. Grind all valve seats. See VALVE SEATS, Grinding Valve Seats section.

14. Clean the cylinder assembly and make certain all traces of abrasive material are removed.

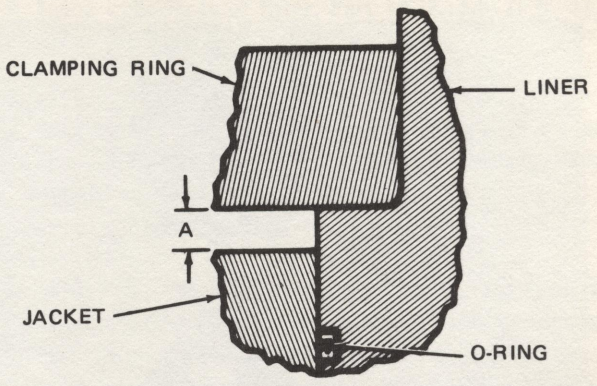
SQUARE-CUT LOWER LINER SEAL

This seal provides a second means of assuring a watertight seal between the lower portion of the liner and the cylinder jacket. It is applicable to annular-groove liners, and is not applicable to belly-band liners.

The seal may be applied to cylinders removed from an engine to correct a lower-liner seal problem, or it may be applied to cylinders being rebuilt. It has been applied to all new and factory-rebuilt cylinders since mid-1973. For all cylinders the application procedure is the same and is as follows:

1. Position the cylinder so the liner extension is vertical and the bottom of the liner is facing up.

2. Measure and record the minimum space between the clamping ring and the cylinder jacket. This is dimension "A" on Fig. 42. Measure adjacent to one of the clamping-ring bolts.



NOTE:
CROSS-SECTIONS SHOWN
WITH CYLINDER INVERTED.

FIG. 42. MEASURING SPACE FOR SQUARE-CUT O-RING.

FIG. 42, E-21137

3. Loosen the clamping-ring bolts, then carefully remove the bolts and clamping ring.

4. If the cylinder was one removed for repair, clean the area with mineral spirits, or an equivalent solvent.

5. Select the proper O-ring from Table I and position it as shown in Fig. 43. Check to assure there is no twist in the O-ring when it is in position.

6. Select the proper number of retaining rings from Table I, and position them around the outside diameter of the O-ring. See Fig. 44. Align the slots in the rings to expose all clamping-ring bolt holes in the cylinder jacket.

7. Carefully reapply the clamping ring and secure with bolts. Tighten the bolts in a criss-cross pattern up to the final, cold torque value specified under the assembly method (A or B) used.

TABLE I, USE OF SQUARE-CUT O-RINGS AND RETAINING RINGS

"A" Dimension Found Between	O-Ring Part Number	Axial Thickness	O-Ring Color Code	Quantity of 121X1167-1 Retaining Rings
0.175 and 0.150 in.	121X1164-1	0.200 in.	Total Green	3
0.149 and 0.120 in.	121X1178	0.175 in.	Black Band	2
0.119 and 0.095 in.	121X1165-1	0.150 in.	Red Band	2
0.094 and 0.070 in.	121X1179	0.125 in.	White Band	1
0.069 and 0.045 in.	121X1166-1	0.100 in.	Yellow Band	1

FIG. 45, E-22759

FIG. 44, E-21139

FIG. 43, E-21138

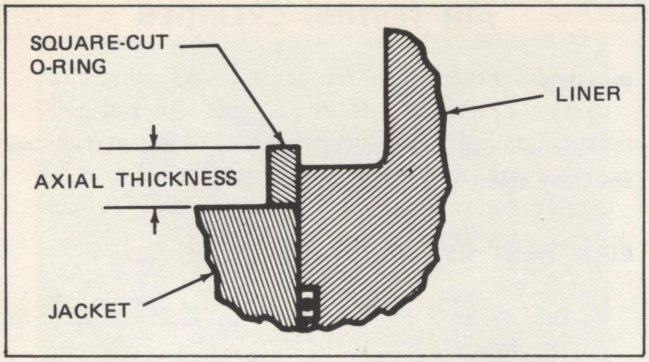


FIG. 43. INSTALL SQUARE-CUT O-RING.

COMPRESSION RELEASE VALVE

GENERAL

Two arrangements of this device have been used. The old-style valve is shown in Fig. 45, while the new-style valve is shown in Fig. 46. Either style will fit old or new cylinder assemblies. The plugs of both styles are interchangeable, thus making it possible to create two additional arrangements.

MODIFICATION OF OLD ADAPTERS

Early-production adapters had a square corner on the inboard end of the 0.937/0.932-in. diameter. This square corner could sometimes cut the O-ring at assembly. Later-production adapters had a 15-degree chamfer machined at this location to avoid damaging the O-ring. All adapters should have this sharp corner removed before reusing in a cylinder. See Fig. 47.

INSTALLATION – OLD STYLE VALVE (Fig. 45)

1. Clean threads in cylinder head and on adapter.

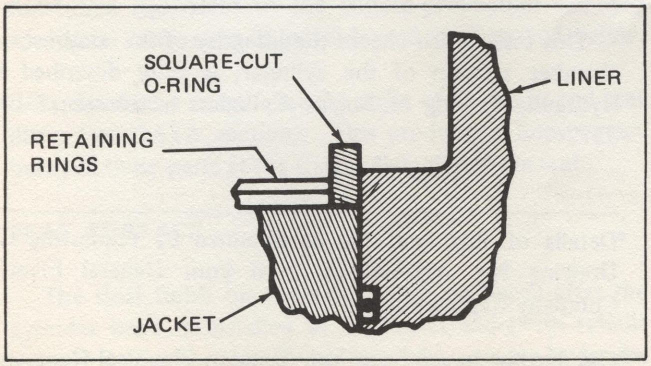


FIG. 44. APPLY RETAINING RINGS.

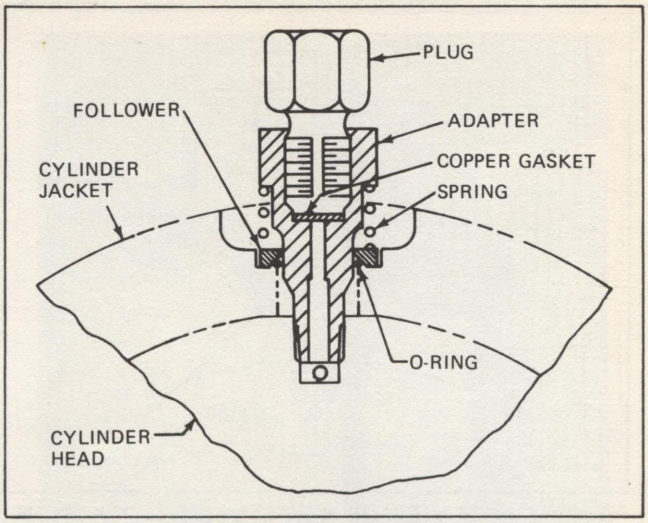


FIG. 45. TOP VIEW OF OLD-STYLE COMPRESSION RELEASE VALVE.

2. Apply a few drops of Loctite* No. 601 (GE Part 147X1898-1) to the adapter threads.

3. Apply Lubriplate Spray Lube "A" (GE Part 147X-1614) to the O-ring.

4. Position the spring, follower and O-ring on the adapter. While compressing the spring, thread the adapter thru the cylinder jacket hole into the threaded hole in the cylinder head. Use adapter drive, Part 147X1879, and torque to 60-65 lb.-ft. (81-88 N•m).

5. Apply a film of Molydag No. 210 to plug threads. Refer to INSTALLING HEAD AND LINER INTO JACKET section for method of applying this lubricant to threads.

6. Lightly coat a new copper gasket with grease and insert it into the adapter. Apply the plug but do not tighten at this time, since it must be removed to perform subsequent operations.

INSTALLATION – NEW STYLE VALVE (Fig. 46)

1. Install set screws in the adapter.

2. Clean threads in cylinder head and on adapter.

3. Apply a few drops of Loctite No. 601 (GE Part 147X1898-1) to the adapter threads.

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*Product of Loctite Corp.

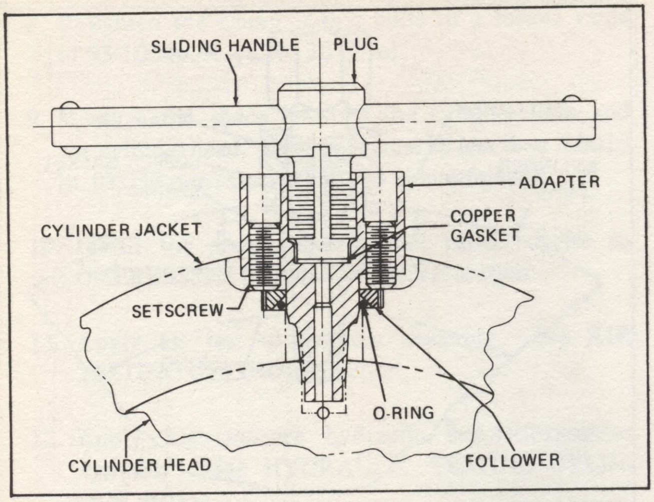

FIG. 46. TOP VIEW OF NEW-STYLE COMPRESSION RELEASE VALVE.

FIG. 46, E-22580

4. Apply Lubriplate Spray Lube "A" (GE Part 147X-1614) to the O-ring.

5. Position the follower and O-ring on the adapter. Install the adapter thru the cylinder jacket hole, and thread it into the tapped hole in the cylinder head. Using spanner wrench, Part 147X1991, torque the adapter to 60-65 lb.-ft. (81-88 N•m).

6. Tighten each set screw to a torque value of 15-20 lb.-ft. (20-27 N•m).

7. Apply a film of Molydag No. 210 to plug threads. Refer to INSTALLING HEAD AND LINER INTO JACKET section for method of applying this lubricant to threads.

8. Lightly coat a new copper gasket with grease and insert it into the adapter. Apply the plug, but do not tighten at this time, since it must be removed to perform subsequent operations.

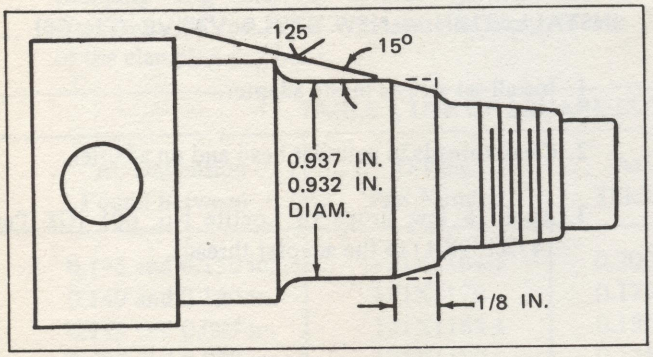

FIG. 47. ADAPTER MODIFICATION TO AVOID O-RING DAMAGE.

FIG. 47, E-22760

AIR TESTING CYLINDER

PURPOSE

This test checks the integrity of the water passages and seals contained in the cylinder assembly.

EQUIPMENT REQUIRED

1. One 48 in. x 36 in. x 36 in. test tank similar to the one shown in Fig. 49.*

2. Approximately 225 gallons of water solution – one part Vantrol 915 grinding fluid** (or an equivalent synthetic, water soluble, rust inhibitor) mixed with 50 parts water.

TESTING

1. With the head and liner assembled in the jacket, apply a blanking flange to the water discharge opening of the cylinder jacket. See Fig. 48.

2. Assemble a flange with an air connection to the water inlet opening.

3. Connect an air hose to the inlet connection.

4. Lower the cylinder into the tank until the clamping ring is completely submerged.

5. Apply 35-45 psi air for a minimum of five minutes. If no bubbles appear in the tank for five minutes, the cylinder assembly is satisfactory. If any bubbles appear, correct the leak and retest.

HYDRAULIC TESTING CYLINDER

This test, which checks the integrity of the combustion-chamber portion of the cylinder, is fully described in Hydraulic Testing of Engine Cylinders instruction, GEK-35776.

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*Details of this tank can be obtained by requesting GE Drawing No. 41D780248 from your General Electric Company Representative.

**Can be purchased from Van Straaten Chemical Company, 630 West Washington Blvd., Chicago, Illinois 60606

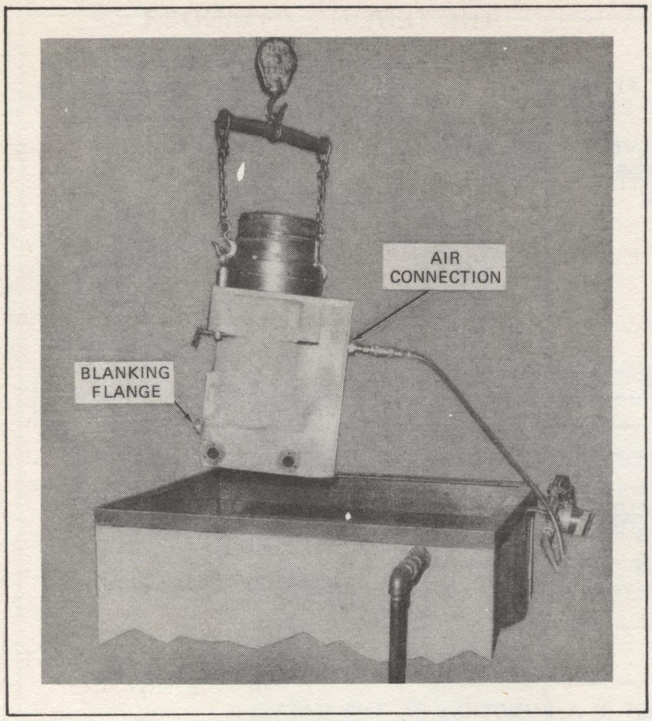

FIG. 48. CYLINDER PREPARED FOR TANK.

FIG. 48, E-15155

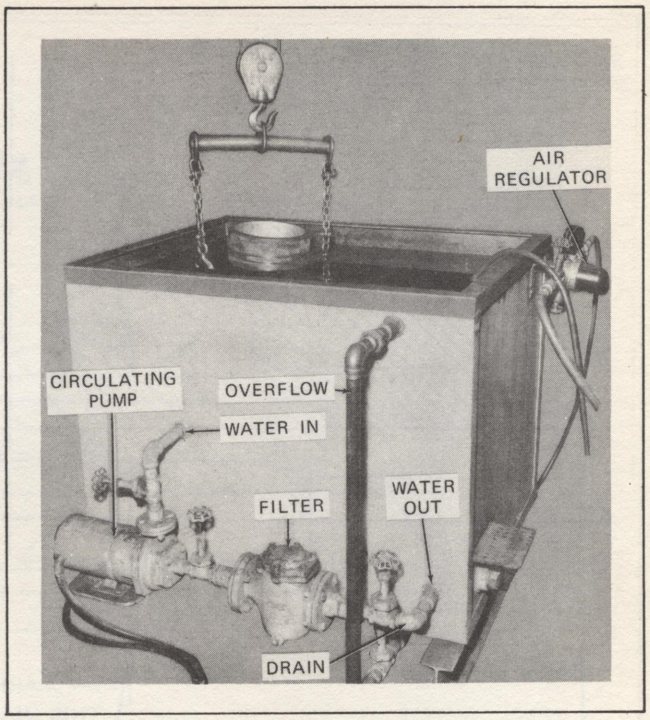

FIG. 49. CYLINDER BEING TESTED AND TANK DETAILS.

FIG. 49, E-15156

VALVE SEATS

GENERAL

Four valve seats, produced by hard-face welding, heat treatment and grinding, are an integral part of each cylinder head. Seats can ordinarily be reground several times before reaching the condemning limit, when the head must be scrapped or returned to our factory for re-hard-facing.

Inlet valve seats can be either 45 degrees (nominal) or 15 degrees (nominal). All exhaust valve seats are 45 degrees (nominal).

Conversion of older 45-degree inlet valve seats to the functional equivalent of the current-production standard 15-degree valve seats is possible and is described below.

It should be noted that the angle of the valve and seat differ (see DATA section). This produces a line contact between these parts at the largest diameter of the seat.

SEAT SURFACE

The final finish on the valve seat is produced after the cylinder head is installed in the jacket and (with rebuilt cylinders) after the cylinder has been high-pressure hydraulic tested.

The final finish is produced by grinding only. It must be a 63 microinch finish and must have no waves along its radial length in excess of 0.0002 in. peak to valley.

Pin holes or pits in the valve seat surface are not permitted under the following conditions:

1. Pin holes or pits cannot exceed 1/32-in. diameter
2. Three holes in line are not acceptable
3. Holes cannot be closer than 1/32 in. to one another
4. Not more than 5 holes are permitted in the total valve seat surface
5. No holes are permitted in the seat surface within 1/16 in. of the valve contact line.

SEATING VALVES IN VALVE SEATS

An individual valve must be selected and applied to its own seat. Grind valve seat to attain the correct angle and finish. Valve must overhang its seat all around a minimum of 0.005 in. If valve seats have been reground to the extent the overhang value cannot be attained, create additional clearance, and valve overhang, by one of the following methods:

1. For 45-degree seats, grind a 30-degree clearance angle on the outer portion of the valve seat. See Fig. 50.

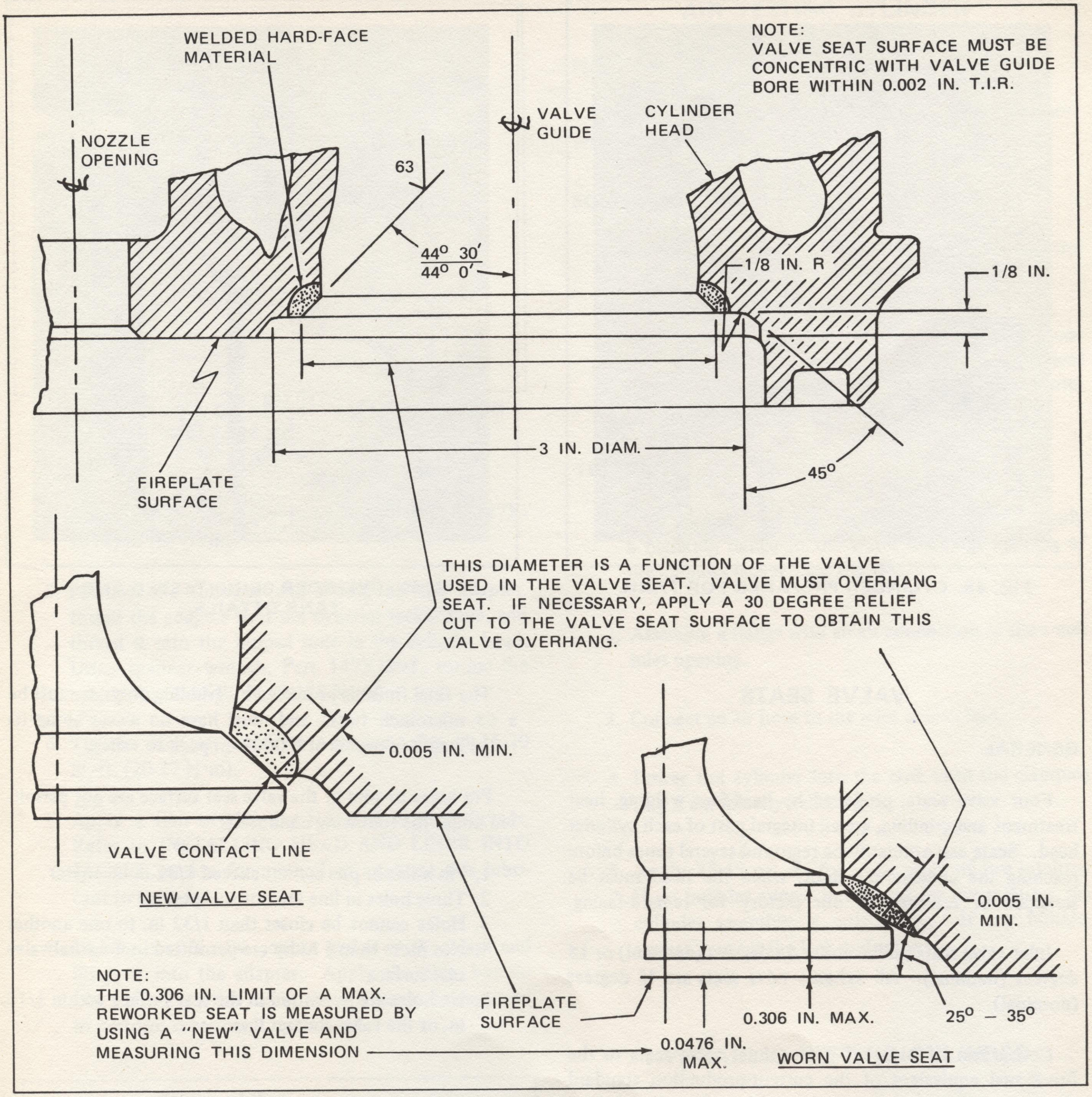
WELDED HARD-FACE MATERIAL
NOTE: VALVE SEAT SURFACE MUST BE CONCENTRIC WITH VALVE GUIDE BORE WITHIN 0.002 IN. T.I.R.
VALVE GUIDE
CYLINDER HEAD
NOZZLE OPENING
63
44° 30′
44° 0′
1/8 IN. R
1/8 IN.
3 IN. DIAM.
45°
FIREPLATE SURFACE
THIS DIAMETER IS A FUNCTION OF THE VALVE USED IN THE VALVE SEAT. VALVE MUST OVERHANG SEAT. IF NECESSARY, APPLY A 30 DEGREE RELIEF CUT TO THE VALVE SEAT SURFACE TO OBTAIN THIS VALVE OVERHANG.
0.005 IN. MIN.
VALVE CONTACT LINE
NEW VALVE SEAT
0.005 IN. MIN.
NOTE: THE 0.306 IN. LIMIT OF A MAX. REWORKED SEAT IS MEASURED BY USING A "NEW" VALVE AND MEASURING THIS DIMENSION
FIREPLATE SURFACE
0.306 IN. MAX.
25° – 35°
0.0476 IN. MAX.
WORN VALVE SEAT

FIG. 50, E-22762

FIG. 50. 45-DEGREE (NOMINAL) VALVE SEAT DETAILS.

2. For 15-degree seats, deepen the counterbore to a maximum of 3/16 in. See Fig. 51.

After creating additional clearance by either of the preceding methods, finish grind the working surface of the seat.

GRINDING VALVE SEATS

NOTE: *CYLINDER HEAD MUST BE INSTALLED IN CYLINDER JACKET WHEN FINISH-GRINDING VALVE SEATS.*

The quality and integrity of the valve seats will depend, to a large extent, on the use of proper tooling. Such tooling is available and is fully described in the Locomotive Maintenance Tools Catalog, GEG-14700B.

To achieve the 63 microinch finish specified for the seat surfaces:

1. Use appropriate grinding wheels. These are available as Part 147X1881 (rough) and Part 147X1882

FIG. 51, E-22763

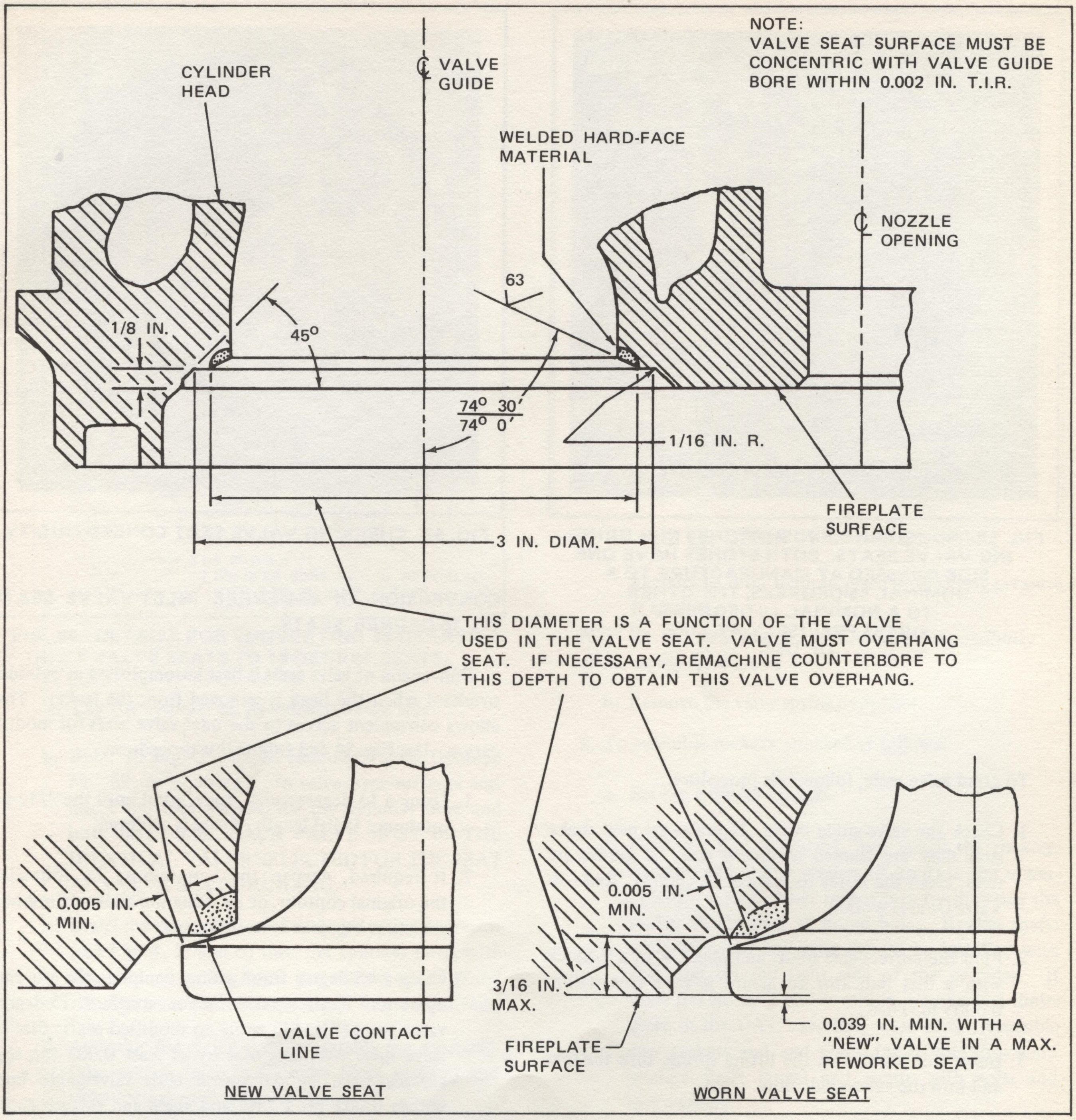
CYLINDER HEAD
℄ VALVE GUIDE
NOTE:
VALVE SEAT SURFACE MUST BE CONCENTRIC WITH VALVE GUIDE BORE WITHIN 0.002 IN. T.I.R.
WELDED HARD-FACE MATERIAL
℄ NOZZLE OPENING
63
1/8 IN.
45°
74° 30′
74° 0′
1/16 IN. R.
FIREPLATE SURFACE
3 IN. DIAM.
THIS DIAMETER IS A FUNCTION OF THE VALVE USED IN THE VALVE SEAT. VALVE MUST OVERHANG SEAT. IF NECESSARY, REMACHINE COUNTERBORE TO THIS DEPTH TO OBTAIN THIS VALVE OVERHANG.
0.005 IN. MIN.
VALVE CONTACT LINE
NEW VALVE SEAT
0.005 IN. MIN.
3/16 IN. MAX.
FIREPLATE SURFACE
0.039 IN. MIN. WITH A "NEW" VALVE IN A MAX. REWORKED SEAT
WORN VALVE SEAT

FIG. 51. 15-DEGREE (NOMINAL) VALVE SEAT DETAILS.

(finish). Both have the 45-degree and 15-degree seat angle rough-formed in the stone (Fig. 52). A 30-degree relief-angle wheel, Part 147X1061, is also available.

2. Correctly dress the wheel prior to grinding. This is best accomplished by using the dressing tool with pneumatic feed, Part 147X1883.

3. Dress the grinding wheels to the specified angle as often as necessary when grinding to maintain the correct face angle and to produce a high-quality seat face. THIS MAY BE AS OFTEN AS ONE DRESSING FOR EACH SEAT GROUND.

4. Apply only light pressure to the wheel during grinding, to avoid loading the wheel and, thus, producing an irregular face.

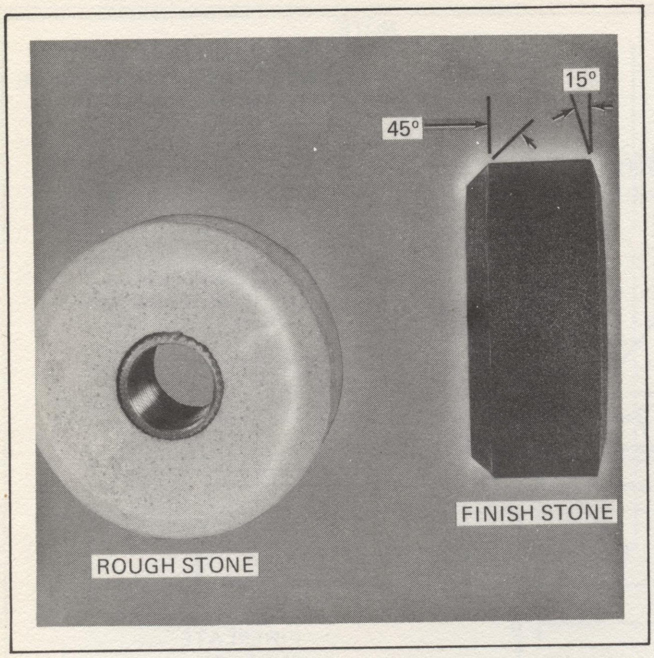

FIG. 52. ROUGH AND FINISH STONES FOR GRINDING VALVE SEATS. BOTH STONES HAVE ONE SIDE DRESSED AT MANUFACTURE TO A NOMINAL 45-DEGREES, THE OTHER TO A NOMINAL 15-DEGREES. DRESS PRECISELY AT TIME OF USE.

FIG. 52, E-22636

To grind valve seats, follow this procedure:

1. Check the valve-guide bores. If guides are new, make sure they are reamed to proper size. If guides are used, clean the bores to remove all carbon. Refer to Valve Guides section.

2. Find the correct-size pilot, and check it in a V-block with a dial indicator to assure it runs true within 0.0005 in. T.I.R.

3. Insert this pilot, with the lifting spring, thru the seat and into the valve-guide bore.

4. Grind the seat. Use the rough wheel if considerable grinding is required, followed by the finish wheel to complete the grinding operation. Refer to Fig. 50 and 51 for seat details. Check the concentricity of the seat with dial indicator, Part 147X1050 (Fig. 53), which cannot exceed 0.002 in. T.I.R.

5. When grinding is completed, clean all abrasive material from the head area and valve ports, using a hose and compressed air. Then, flush the liner, ports and head with a cleaning solution.

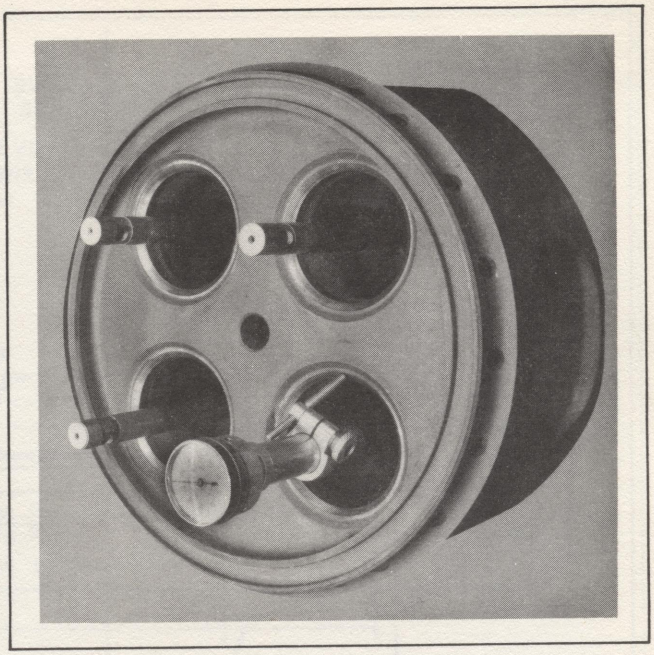

FIG. 53. CHECKING VALVE SEAT CONCENTRICITY.

FIG. 53, E-13563

CONVERSION OF 45-DEGREE INLET-VALVE SEATS TO 15-DEGREE SEATS

Conversion of valve seats is best accomplished at cylinder overhaul when the head is removed from the jacket. This allows convenient access to the inlet-valve seats for modification. Use Fig. 54 and follow this procedure:

1. Using a 15-degree rough stone, grind until the 3/32-in. minimum radial length of seat is achieved.

2. If required, deepen the counterbore by following the original contour, or by using the alternate method shown in Fig. 54.

3. Using a 15-degree finish stone, complete the grinding operation. All conditions for standard 15-degree valve seats (Fig. 51) apply to modified seats; that is, valve must overhang seat by at least 0.005 in., seat surface must be concentric with valve-guide bore within 0.002 in. T.I.R., and angle and surface finish must be correct.

4. After cylinder head is installed in the jacket, the modified 15-degree inlet-valve seats will require a touch-up refinishing grind operation.

INSTALLING VALVES AND UPPER CYLINDER COMPONENTS

1. To assemble the valves, proceed as follows:

FIG. 55, E-22767

FIG. 54, E-22635A

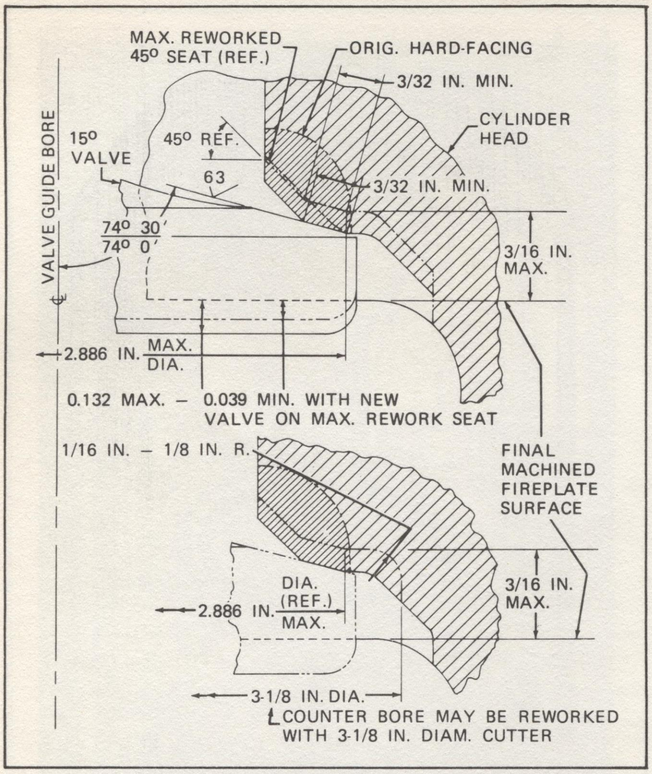
MAX. REWORKED
45° SEAT (REF.)
ORIG. HARD-FACING
3/32 IN. MIN.
CYLINDER
HEAD
15°
VALVE
45° REF.
63
3/32 IN. MIN.
VALVE GUIDE BORE
74° 30′
74° 0′
3/16 IN.
MAX.
2.886 IN. MAX. DIA.
0.132 MAX. – 0.039 MIN. WITH NEW
VALVE ON MAX. REWORK SEAT
1/16 IN. – 1/8 IN. R.
FINAL
MACHINED
FIREPLATE
SURFACE
DIA.
2.886 IN. (REF.)
MAX.
3/16 IN.
MAX.
3-1/8 IN. DIA.
COUNTER BORE MAY BE REWORKED
WITH 3-1/8 IN. DIAM. CUTTER

FIG. 54. DETAILS FOR CONVERTING 45-DEGREE INLET-VALVE SEATS TO 15-DEGREE SEATS.

a. Lay the cylinder on its exhaust outlet side.

b. Refer to Fig. 55, apply Hercules* Moly Duolube No. 69, or equivalent, to valve-stem surfaces and insert the four valves thru the cylinder bore and into their guides. EACH VALVE MUST BE THE IDENTICAL VALVE SELECTED FOR THE SEAT AT VALVE SEAT GRINDING.

c. Insert the lower portion of the valve spring depressor (see Fig. 4, 5, and 6) thru the cylinder bore, with the stud extending thru the nozzle opening and the depressor in contact with all four valve heads.

d. Assemble the spring seats (preferably the spectacle-type seat – refer to Cylinder Head section) and valve springs over the valve stems.

e. Assemble unbrellas on the inlet-valve stems with the large diameter facing the cylinder head.

f. Assemble retainers on each inlet-valve stem. Install retainers, or rotators, on each exhaust-valve stem. Apply the upper portion of the spring depressor used and secure.

g. Compress the spring(s) and apply new valve keepers. Apply a film of grease to the inside diameter of keepers to hold them in place until spring pressure is applied.

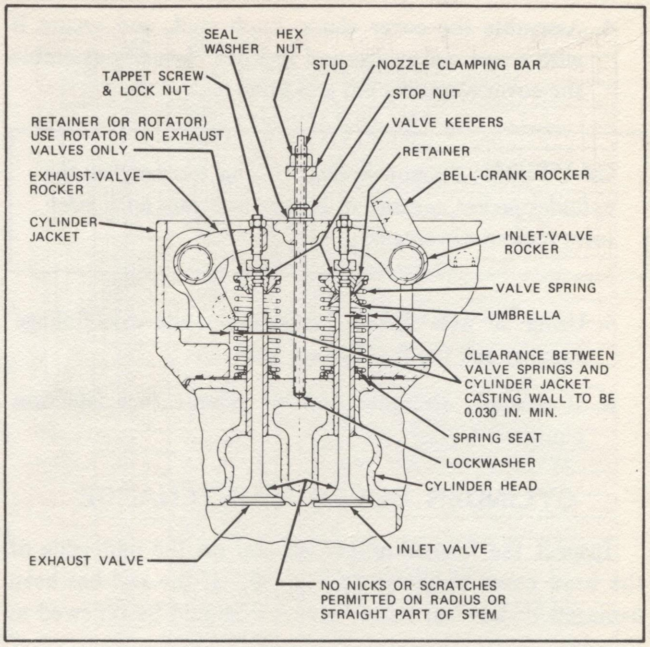
SEAL
WASHER
HEX
NUT
STUD
NOZZLE CLAMPING BAR
TAPPET SCREW
& LOCK NUT
STOP NUT
VALVE KEEPERS
RETAINER (OR ROTATOR)
USE ROTATOR ON EXHAUST
VALVES ONLY
RETAINER
EXHAUST-VALVE
ROCKER
BELL-CRANK ROCKER
CYLINDER
JACKET
INLET-VALVE
ROCKER
VALVE SPRING
UMBRELLA
CLEARANCE BETWEEN
VALVE SPRINGS AND
CYLINDER JACKET
CASTING WALL TO BE
0.030 IN. MIN.
SPRING SEAT
LOCKWASHER
CYLINDER HEAD
INLET VALVE
EXHAUST VALVE
NO NICKS OR SCRATCHES
PERMITTED ON RADIUS OR
STRAIGHT PART OF STEM

FIG. 55. UPPER CYLINDER DETAILS.

NOTE: *Use new keepers to minimize the possibility of damaging valve stems.*

h. Remove the valve spring depressor.

2. To assemble rockers, proceed as follows:

a. Set the cylinder upright.

b. Refer to Fig. 3 and 55, and install the rockers, spacers, and thrust washer (if used) in the upper-cylinder cavity. Hold in position by inserting the rocker shafts thru all bored holes. Rocker shafts with only one end tang should be installed with the tang on the right side of the cylinder. If shaft has no tang and is within dimensional limits given in the DATA section, reuse as is. Assemble new gaskets and end plates (with slots to accommodate shaft tangs) and secure with bolts and lockwashers.

c. Assemble tappet screws and their locknuts in the rocker arms. Back screws out to maximum position and leave locknuts loose. This will facilitate installation of push rods when the cylinder is installed in the engine.

3. In the two stud holes, for the nozzle clamping bar, apply a No. 12 lockwasher. Then assemble the two studs against these lockwashers. Apply new seal washers and locknuts to the studs and lock tightly against the top surface of the jacket casting.

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*Product of the Richardson Co.

4. Assemble the cover clamp knob stud, and secure it with a new seal washer and locknut. Loosely assemble the cover clamping bar and knob.

> **CAUTION:** *Do not thread this stud too far thru the cylinder jacket casting, as it may interfere with inlet-valve rocker movement.*

5. Using a new gasket, reassemble the fuel-linkage support and the fuel linkage lever.
6. If desired, assemble new or rebuilt fuel injection equipment.

CYLINDER COVER MAINTENANCE

Inspect the formed-rubber oil seal on the underside of the head cover as shown in Fig. 56. If the seal has been damaged or has lost its resiliency, it should be renewed as follows:

1. Remove the oil seal and thoroughly clean the groove.
2. Apply rubber bonding cement, Part 115X1030-1 to the groove. Insert a new seal and place the cover, seal down, on a flat surface. Apply weight to hold the seal in place while the cement sets (approximately 1 hour).

NOTE: *Gasket has a radiused and a flat surface. Radiused face must be fitted into the cover groove.*

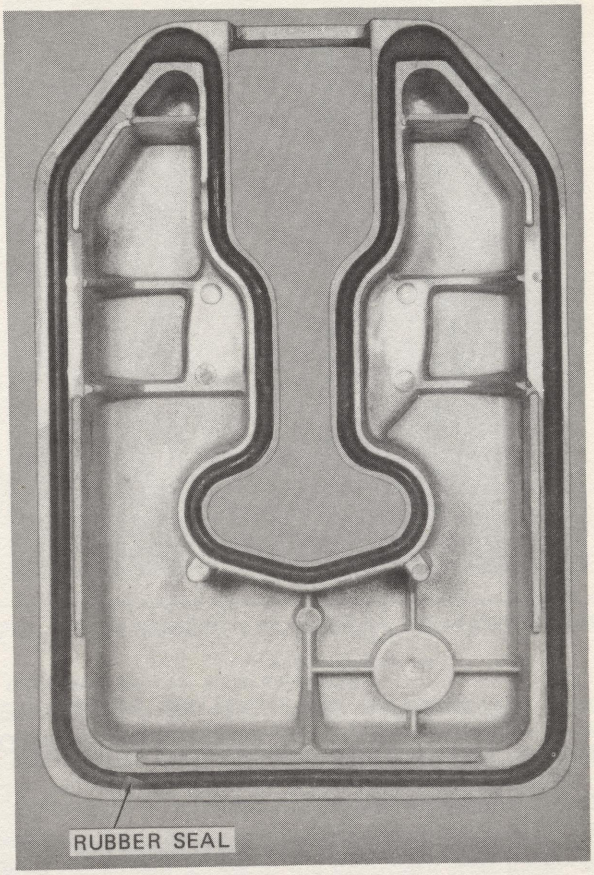


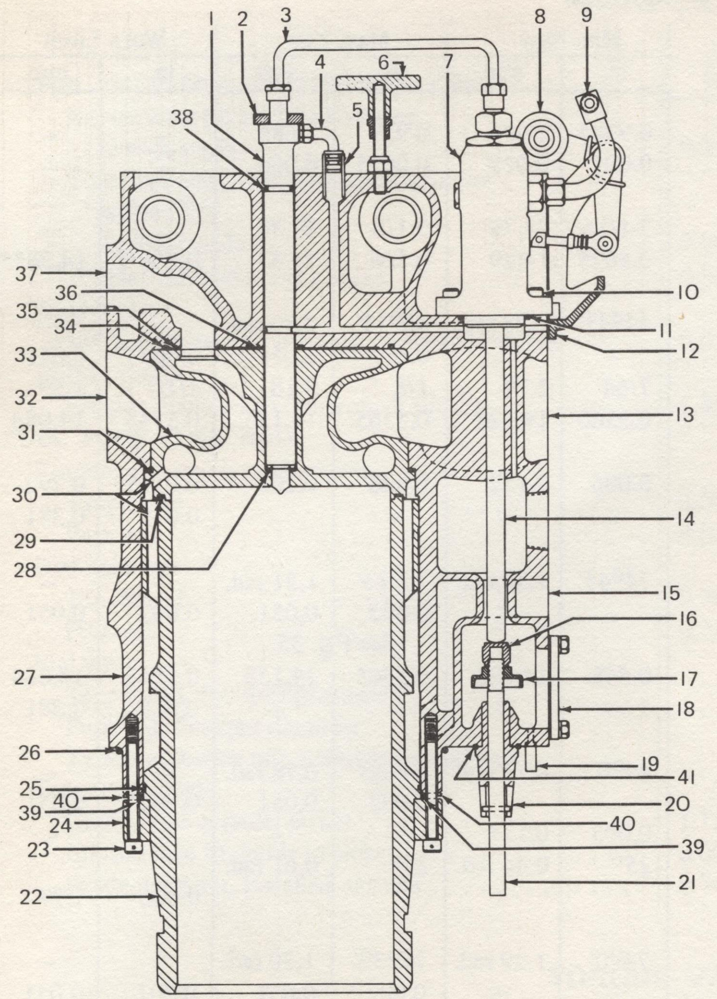
FIG. 56. CYLINDER COVER, INTERNAL VIEW.

FIG. 56, E-9954

DATA

	Min. New		Max. New		Worn Limit	
	in.	mm	in.	mm	in.	mm
BASIC CYLINDER COMPONENTS						
Cylinder jacket (Fig. 9)						
Inside diameter A	0.004	0,102	10.501	266,73		
Inside diameter B	11.499	292,07	11.501	292,13		
Inside diameter C	11.521	292,63	11.523	292,68		
Inside diameter D	11.528	292,81	11.533	292,94		
Inside diameter F	1.265	32,13	1.270	32,26		
Cylinder head (Fig. 9 & 13)						
Outside diameter A	10.5005	266,71	10.5025	266,76	10.4995	266,69
Cylinder liner						
Outside diameter B (Fig. 9)	11.5015	292,14	11.503	292,18		
Outside diameter C (Fig. 9)	11.5225	292,67	11.524	292,71		
Inside diameter E, assembled (Fig. 9)	8.998	228,55	9.005	228,73	9.012	228,90
Inside diameter E, assembled,						
Max. out-of-roundness	–	–	–	–	0.006	0,152
Max. depth of step at ring reversal area	–	–	–	–	0.006	0,152
Clamping ring						
Thickness	1-43/64	42,44	1-45/64	43,26	1-41/64	41,66

FIG. 57, E-14985A



REF.	DESCRIPTION
1	FUEL-INJECTOR NOZZLE
2	INJECTOR-NOZZLE CLAMPING BAR
3	HIGH-PRESSURE FUEL LINE
4	INJECTOR-NOZZLE DRAIN
5	FUEL DRAIN PASSAGE
6	CYLINDER-COVER CLAMPING HANDLE
7	FUEL-INJECTION PUMP
8	FUEL LINKAGE LEVER
9	FUEL-LINE CONNECTION
10	FUEL-PUMP MOUNTING BOLTS
11	FUEL-PUMP SEAL RING
12	FUEL LINKAGE MOUNTING BRACKET
13	AIR INLET OPENING
14	FUEL-PUMP PUSH ROD
15	WATER INLET OPENING
16	TAPPET-ROD ADJUSTING NUT
17	TAPPET-ROD UMBRELLA AND LOCKNUT
18	INSPECTION PLATE WITH GASKET
19	CYLINDER-TO-FRAME FUEL DRAIN SLEEVE
20	TAPPET-ROD GUIDE
21	FUEL-PUMP TAPPET ROD
22	CYLINDER LINER
23	LINER CLAMPING-RING BOLTS
24	CYLINDER-LINER CLAMPING RING
25	O-RING (LINER TO JACKET)
26	O-RING (CYLINDER JACKET TO MAIN FRAME)
27	CYLINDER JACKET
28	INJECTOR-NOZZLE GASKET (COPPER)
29	GASKETS (2) (LINER TO CYLINDER HEAD)
30	COOLING-WATER PASSAGES
31	CYLINDER HEAD-TO-JACKET WATER SEAL
32	EXHAUST GAS PASSAGE
33	CYLINDER HEAD
34	SEAL (UPPER, CYLINDER HEAD TO JACKET)
35	SEAL (WATER DISCHARGE OPENING - HEAD TO JACKET)
36	SEAL (INJECTOR-NOZZLE OPENING - HEAD TO JACKET)
37	WATER DISCHARGE OPENING
38	SEAL BETWEEN NOZZLE AND UPPER CYLINDER JACKET)
39	O-RING (LINER TO JACKET & CLAMPING RING)
40	RETAINING RING(S)
41	O-RING (TAPPET-ROD GUIDE TO MAIN FRAME)

FIG. 57. CYLINDER ASSEMBLY, SECTIONAL VIEW.

DATA (Cont'd.)

BASIC CYLINDER COMPONENTS (Cont'd.)

Fit requirements	Interference				Clearance			
	Max.		Min.		Max.		Min.	
	in.	mm	in.	mm	in.	mm	in.	mm
Cylinder head to jacket at diam. A	0.004	0,102	–	–	0.0015	0,038	–	–
Cylinder liner to jacket at diam. B	0.004	0,102	0.0005	0,013	None Permitted			
Cylinder liner to jacket at diam. C	0.003	0,076	–	–	0.0005	0,013	–	–
Cylinder liner to head, assembled and before high-pressure test, around total circumference					0.0015	0,038	–	–
Cylinder liner to head, assembled and after high-pressure test, only one gap less than 3 in. (76mm) long permitted					0.0015	0,038	–	–

DATA (Cont'd.)

UPPER CYLINDER COMPONENTS	Min. New in.	Min. New mm	Max. New in.	Max. New mm	Worn Limit in.	Worn Limit mm
Valve guides (four)						
Outside diameter	0.9385	23,84	0.939	23,85	–	–
Interference fit in head	0.001	0,025	0.0025	0,064	–	–
Position, top surface of head to top of guide	3-1/16	77,79	3-1/8	79,38	–	–
Inside diameter, installed, reamed size*	0.5625	14,29	0.564	14,33	0.566**	14,38**
Valves – 45-degree inlet and exhaust						
Face angle	44°45′	0,78 rad.	45°15′	0,80 rad.	–	–
Face concentricity (to stem)	–	–	0.002	0,051	0.002	0,051
Edge thickness	7/64	2,77	1/8	3,18	1/16	1,59
Stem diameter	0.5560	14,122	0.5565	14,135	0.5545	14,084
Running clearance on diameter, valve stem to guide	0.006	0,152	0.008	0,203	0.0115	0,292
Head flatness	–	–	–	–	0.015	0,381
Valves – 15-degree inlet						
Face angle	74°45′	1,30 rad.	75°15′	1,31 rad.	–	–
Face concentricity (to stem)	–	–	0.002	0,051	0.002	0,051
Edge thickness			See Fig. 35			
Stem diameter	0.556	14,122	0.5565	14,135	0.5545	14,084
Head flatness	–	–	–	–	0.015	0,381
Valve seats – 45-degree inlet and exhaust						
Face angle	44°0′	0,77 rad.	44°30′	0,78 rad.	–	–
Seat concentricity to valve guide bore			0.002	0,051	0.002	0,051
Overhang – valve over seat	0.005	0,127	–	–	–	–
Relief angle – to produce valve overhang	25°	0,44 rad.	35°	0,61 rad.		
Seat depth – from fireplate surface					0.306	7,772
Valve seats – 15-degree inlet						
Face angle	74°0′	1,29 rad.	74°30′	1,30 rad.	–	–
Seat concentricity to valve guide bore	–	–	0.002	0,051	0.002	0,051
Overhang – valve over seat	0.005	0,127	–	–	–	–
Counterbore depth – from fireplate surface (1/8 in. nominal)	0.109	2,77	0.140	3,56	0.188	4,76
Valve spring						
Free length, new (5-41/64 in. nominal)	5-37/64	141,69	5-45/64	144,86	–	–
Free length, used (5-33/64 in. nominal)	5-29/64	138,51	5-37/64	141,69	–	–
Length, with initial load of 271 lb. (123 kg) (4-15/16 in. nominal)	4-59/64	124,99	4-61/64	125,81	–	–
Length, with final load of 555 lb. (252 kg) (4-17/64 in. nominal)	4-1/4	107,95	4-9/32	108,74	–	–
Rockers (inlet, exhaust, bell-crank)						
Running clearance on shaft (old style)	0.001	0,025	0.003	0,076	0.008	0,203
Running clearance on shaft (new style)	0.002	0,051	0.004	0,102	0.008	0,203
Bushing bore, installed, honed (old style)	1.4995	38,09	1.5005	38,11	1.505	38,22
Bushing bore, installed, honed (new style)	1.5005	38,11	1.5015	38,14	1.505	38,22
Bushing bore in rocker (all)	1.6865	42,84	1.688	42,88	–	–
Interference fit, bushing in rocker (old style)	0.0005	0,013	0.003	0,076	–	–
Interference fit, bushing in rocker (new style)	0.0015	0,038	0.004	0,102	–	–
Push-rod bearing bore in rocker (all)	1.1245	28,562	1.1255	28,588	–	–

*Check with 0.5615 in. (14,26mm) "go" gage which must pass freely thru the full length.

**Measured at a distance of 1/2 in. (12,7mm) from each end.

DATA (Cont'd.)

	Min. New		Max. New		Worn Limit	
UPPER CYLINDER COMPONENTS (Cont'd.)	in.	mm	in.	mm	in.	mm
Interference fit, push-rod bearing in rocker (all)	0.0002	0,005	0.0017	0,043	–	–
Total end-play, rocker(s) inside cylinder jacket (all)						
Exhaust rocker	0.004	0,102	0.020	0,508	0.023	0,584
Inlet and bell-crank rockers	0.004	0,102	0.023	0,584	0.027	0,686
Tappet screw						
Vertical movement between screw and bearing	0.030	0,762	0.090	2,286	0.095	2,413
Rocker shafts						
Outside diameter (32 microinch finish)	1.4975	38,037	1.4985	38,062	1.497	38,023
FUEL PUMP PUSH ROD						
Running clearance, on diameter						
Tappet rod	0.001	0,025	0.0015	0,038	0.007	0,078
Push rod	0.0009	0,023	0.0036	0,091	0.007	0,078
Rod diameter						
Tappet rod	0.748	18,999	0.7485	19,012	0.745	18,922
Push rod	0.7454	18,933	0.7461	18,951	0.742	18,846
End wear						
Tappet rod, flat-spot diameter					9/16	14,29
Push rod, flat-spot diameter					9/16	14,29
Tappet adjusting nut, hallow-spot diameter					9/16	14,29
Tappet-rod guide						
Guide fit in cylinder jacket	1.1245	28,562	1.1255	28,588	–	–
Interference fit, guide in jacket	0.001	0,025	0.0025	0,064	–	–
Inside diameter, installed, reamed	0.7495	19,037	0.7505	19,063	–	–

TORQUE VALUES

	Lb.-Ft.	N·m
Liner clamping-ring bolts		
At assembly, jacket hot (method "A")	85-90	115-122
At retorque, jacket cool (method "A")	70-75	95-102
At assembly, jacket hot (method "B")	85-90	115-122
At retorque, jacket cool (method "B")	95-100	129-136
Rocker-shaft end-plate bolts	30-35	41-47
Nozzle clamping bar studs	55-60	75-81
Nozzle mounting nuts	30-35	41-47
Fuel injection pump mounting bolts	45-50	61-68
High-pressure fuel-line nuts (large fuel system)	140-150	190-203
High-pressure fuel-line nuts (small fuel system)	65-70	88-95
Tappet-screw locknuts	50-55	68-75
Compression-release adapter	60-65	81-88
Compression-release adapter set screws (new style)	15-20	20-27
Compression-release plug	20-25	27-34